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ABSTRACT

The two-year curriculum in chemical technology presented in the document is designed to prepare high school graduates for technical positions in the chemical industry. Course outlines are given for general chemistry, chemical calculations, quantitative analysis, environmental chemistry, organic chemistry 1 and 2, instrumental analysis, and physical chemistry. Each course combines lectures and laboratory experiments and includes methodology, suggested textbooks, student evaluation, a sample lesson plan, and syllabus. Also provided are general references for the program, periodicals, government publications, audiovisual aids, teacher preparation, and suggested field trips and guest lectures. The graduate of this program in chemical technology receives an associate in applied science degree. (Author/MF)

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CHEMICAL

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ENVIRONMENTAL TECHNOLOGY

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CHEMICAL AND ENVIRONMENTAL TECHNOLOGY

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TEACHER PREPARATION

The teacher will prepare lesson plans for each lecture and make certain that all chemicals, equipment and instrumentation are ready for lab work. He shall have all relevant instructional materials at hand and make notes about any particular safety precautions which he will relate to the students before they start their lab work. He will also encourage the students to use the library by assigning some outside reading on a subject not yet covered, or having them read about a subject in more depth.

STUDENT ACTIVITIES

1. Lecture Area
    - A. Reading assignments from textbooks before the lecture.
    - B. Taking notes during the lecture.
    - C. Complete homework assignments in such a way that the student can explain his solution to a homework problem to his classmates.
    - D. Study from textbook and notes.
    - E. Be prepared for taking tests and quizzes.
    - F. Reading assignments from sources other than the textbook.

2. Laboratory
    - A. Students will be required to read the lab procedure before performing it and will be prepared to write a short outline of how they plan to do the experiment or take a quiz on what they have read.
    - B. Students are expected to keep complete, neat and up-to-date notebooks.
    - C. Laboratory experiments will be performed according to the procedures which are written, or according to oral instructions by the teacher. To deviate from instructions can be hazardous. If a student shows an interest in changing a procedure or doing something in a different manner than prescribed he is encouraged to discuss his plans with the teacher, who will either allow him to do it with proper precautions or will explain why he should not do it.
    - D. At the end of each laboratory session, each student is expected to clean up his immediate area and assist in the general cleanup of the lab. He should also make sure that the equipment assigned to him is clean and locked up in the lab drawers assigned to him.
    - E. Two students are assigned each week, on a rotating basis, to make sure that the lab is left in a clean condition. Since they are the last two students to leave the lab and have to clean up anything left by other students, it is in their own best interests to see to it that the lab is kept clean.
    - F. The student will be developing and improving on his manipulative skills and his ability to start and complete a job with a minimum of errors.

INTRODUCTION

Applied chemical science has influenced the materials that touch every aspect of our lives. The houses we live in, the clothes we wear, and the food we eat all contain natural raw materials which undergo chemical analysis. New combinations of substances are synthesized to produce medicines to cure or alleviate diseases. Methods are being developed to help man control his environment; he is exploring the unknowns of space and probing the mysteries of life and health. If this work is to continue in the chemical laboratories, a steady influx of skilled technicians is a necessity.

Since the chemical industry is very complex, it is difficult to define the duties of a chemical technician. His duties are so varied that he may use sophisticated instruments one day to make a determination of the atomic arrangement of a molecule and the next day he may be doing color tests in test tubes. Whatever the job, the skill most needed is the ability to make things work. He is the observer and "doer" who translates ideas into practical results.

Chemical technicians are important members of the scientific team who may be working in research, analysis or pilot plant operations. He has a special and indispensable role on the team. He obtains data which proves or disproves the possibility of a new process. He assembles the apparatus, conducts the tests, makes the measurements, and records and reports the data to the chemist, who evaluates it. If an evaluation is favorable, he must be able to initiate variations in the testing procedure and to change or modify the apparatus and equipment. In many cases he must then write a comprehensive and detailed report of his work.

As his skills improve and he gains experience, the technician may be put in full charge of an operation to analyze results and make decisions. He may establish the methods and apparatus for an analysis and be expected to train others in the operation of the equipment.

The special abilities required of a chemical technician are:

1. An extensive knowledge of chemical apparatus, equipment, procedures and techniques, and competency in applying this knowledge.
2. Proficiency in the application of the basic concepts and laws of physics and chemistry.
3. An understanding of the properties of the chemicals he works with.
4. Facility with mathematics; he must be able to use mathematics as a tool in the development of ideas that use chemical and related principles.
5. Communication skills that include the ability to interpret, analyze, and transmit facts and ideas orally, graphically or in writing.
6. The ability to establish rapport with both those he works for and those who work for him.
7. Individual judgement, initiative and resourcefulness.

THE CURRICULUM

The curriculum of this program is designed for high school graduates who are interested in chemistry. They should have successfully completed two years of mathematics and one year of science in their high school program. If a student does not meet the requirements of admission to the program, he may take our pre-technical course which will give him adequate skills in mathematics and English to make satisfactory progress.

The two-year curriculum concentrates on the primary needs of the student to prepare him for a responsible technical position in the chemical industry. It involves a high order of specialization and is designed to provide the maximum technical instruction in the time that is scheduled. This curriculum is structured with three components in mind. First, the training will prepare the graduate to take an entry job in which he will be productive. Second, the training, together with experience, will enable the graduate to advance to positions of increasing responsibility. Third, the training is broad enough to provide the foundation for the student to go on to further study in the field of chemistry. The graduate of this program receives an Associate in Applied Science degree.

This curriculum has five divisions:

1. the core program chemistry courses
2. the specialized chemistry courses
3. mathematics courses
4. physics courses
5. humanities courses

CHEMICAL TECHNOLOGY

First Year

First Semester	L/R	LAB	CR
CH-101 General Chemistry	5	9	8
CH-105 Chemical Calculations	3	0	3
MA-101 Technical Mathematics I	4	0	4
LA-101 Composition I	3	1	3
	15	10	18
Second Semester			
CH-102 Quantitative Analysis	4	6	6
CH-106 Environmental Chemistry	3	0	3
PH-101 Physics I	3	3	4
MA-102 Technical Mathematics II	4	0	4
LA-102 Composition II	3	1	3
	17	10	20

Second Year

Third Semester	L/R	LAB	CR
CH-201 Organic Chemistry I	4	6	6
CH-215 Instrumental Analysis	2	3	3
PH-102 Physics II	3	3	4
MA-205 Technical Mathematics III	3	0	3
Elective-LA	3	0	3
Fourth Semester			
First six weeks on campus			
Ch-202 Organic Chemistry II	4	6	2
Last ten weeks off campus			
CH-290 Chem Tech Field Project	1	20	3
Entire semester on campus			
Ch-225 Physical Chemistry	3	0	3
Elective-LA	3	0	3
Elective	3	0	3
First six weeks	13	6	14
Last ten weeks	10	20	

This book contains the topical course outlines using behavioral objectives for the chemistry courses in the program. Methodology, student evaluation and a sample lesson plan are also included for each course. Also listed are the textbooks, reference books, periodicals, audiovisual aids, suggested field trips, suggested guest lecturers, teacher preparation, and student activities.

OTHER COURSES IN THE PROGRAM

CHEMICAL TECHNOLOGY FIELD PROJECT CH-290

This course is a ten-week, four hours per day externship in the laboratory facilities of a local chemical firm. It takes place in the latter part of the fourth semester after the six-week course in Organic Chemistry II.

Its objective is to provide the student with an actual work experience that will require him to draw upon his study and to apply this knowledge to the job. The student will be working with a chemist in a research or analytical laboratory as part of a team effort to solve a problem. Although all the students who have participated in the course to date have been compensated by the company, this is not guaranteed. If a suitable externship cannot be arranged, a term project will be assigned by the instructor as an alternative.

The student will be evaluated primarily on the recommendations of his work supervisor. The supervisor will be in contact with the department coordinator during the program and will submit a written evaluation of the student's performance near the end of the work experience. In addition, a weekly one-hour seminar on campus is included. Each student will be required to give an oral presentation of his work experience in the class. It is expected that he will be able to demonstrate increased knowledge in chemistry and that he will be able to communicate this knowledge to his fellow students.

ELECTIVE COURSES

During the fourth semester, all students in the Engineering Technology Division are required to take an elective course. Most of them choose to widen their knowledge in some technological field. The chemical technology students have almost unanimously chosen to continue their study of chemistry beyond that covered in the program, by selecting the course Special Topics in Chemical Technology CH-285. The course content is arranged to satisfy the particular needs and interests of the students. For example, one year the course was devoted to polymer chemistry and last year the course went into more advanced topics of organic chemistry.

For the advanced student who is capable of doing individual work and has a Grade Point Average of at least 3.00 after three semesters, the course Independent Study Ch 295 may be selected. This consists of a special research or development project in chemical technology proposed by the student and found acceptable to the department.

If there is such a request, the department is prepared to offer a course to non-Chemical Technology students in the fundamentals of chemistry. Such a course would be tailored to the needs of the students.

METHODOLOGY

The course is taught as a combination of lectures and laboratory experiments. The lectures cover the theoretical aspects of chemistry to enable the student to answer the question, "Why does it happen?", when he makes an observation in the laboratory. Skills and techniques are taught using a series of experiments which at first are quite simple but then become more complex. Each of the first 11 experiments is designed so that only a small amount of theory is necessary. This allows the student more time to concentrate on learning how to handle the equipment properly. From experiment 12 on, the student should have attained some proficiency in the use of his equipment and more theory is involved.

The experiments are performed on an individual basis except where noted. Demonstrations to the entire class are given when appropriate, but more often the instructor will demonstrate a proper procedure to an individual student who may be having difficulty. Close supervision of the students' work is necessary both for reasons of safety and for the development of proper techniques.

TEXT BOOKS

The textbooks for Chemistry 101 are:

1. *Chemistry,* Sienko and Plane, Fourth Edition, McGraw Hill, New York, N. Y., 1971
2. *Properties and Numerical Relationships of the Common Elements and Compounds,* Belcher, Colbert and Rowley, Sixth Edition, Appleton-Century-Crofts, Inc., New York, N. Y., 1962

EVALUATION OF STUDENTS (CH-101)

The students are evaluated on their test results, laboratory performance, laboratory proficiency, laboratory notebook, homework assignments, professional attitude and class participation. A composite grade of 70% would be necessary for the student to receive a letter grade of "C" for the course.

The objectives of this course will be met by written tests. They will be given at the following points:

Test no. 1:	After unit 1.4	1 hour
Test no. 2:	After Section 2	1 hour
Test no. 3:	After Section 3	1 hour
Test no. 4:	After Section 5	1 hour
Test no. 5:	After Section 8	1 hour
Test no. 6:	After Section 10	1 hour
Test no. 7:	After Section 12	1 hour
Final Examination		3 hours

1. Tests

Eight tests, including the final examination, are given during the course at the times specified; unannounced quizzes may be given at any time. A quiz could be anything from a single problem or essay taking 10 minutes up to what might be considered an extra test. Both the tests and the quizzes concentrate upon giving the student an opportunity to give written proof of accomplishment of the behaviorial objectives. After the fourth test, each student is individually counseled concerning his progress to that point. His performance is discussed and if improvement is required he is informed of his deficient areas and what is expected of him in order to receive at least a "C" grade for the course. For students who are not making much progress, counseling is necessary before this time. Tests and quizzes are devised in such a way as to reflect the attainment of the objectives of the course. A student who averages 90 or better will get an "A" for the course. A grade of 75 to 90 would be in the "C" to "B" range. A student scoring between 60 to 75 needs extra help before continuing and one who scores less than 60 is in serious danger of failing the course.

2. Laboratory Performance

A rating sheet for laboratory performance is included as an appendix. It is filled out at least twice during the semester for each student and more frequently if there is any observable improvement or deterioration in a student's performance. If a student gets 125 or better out of a maximum 155 points, he is doing an excellent job in the lab. A score of 100 to 125 indicates that there are some areas that need improvement. When the score is below 100, the instructor will give the student individual counseling to discuss his chances of passing the course.

3. **Laboratory Proficiency**

Manual ability is evaluated by observation of such operations as:

a – Making measurements. For volumetric measurement this includes filling and partially emptying volumetrically calibrated equipment such as cylinders and burets. Reading the bottom of the meniscus accurately and choosing the proper size container for the volume to be measured are other examples of skill observation. Weight measurement includes choosing the proper balance for the job, adjusting it to its zero position, and using the balance gently to avoid sudden jars to its delicate mechanism.

b – Filtering – Proper folding of the filter paper, pouring into the funnel to prevent overflow and placing the funnel stem on the inside of the collection beaker are points to be observed.

c – Washing glassware thoroughly – To prevent possible contamination.

d – Heating a partially filled test tube safely.

e – Transferring – Transferring chemicals from one container to another to avoid contamination. Special emphasis is placed on observing the dispensing of small amounts of liquids with medicine droppers.

f – Proper heating of a crucible.

g – Setting up apparatus according to instructions.

The student will also be questioned frequently to evaluate his ability to relate theory to practice in the laboratory.

4. **Laboratory Notebook**

The notebook is a record of the student's work in the lab and must be kept up to date. It should contain all notes and calculations for the day the experiment was performed. A delay between performance and recording usually results in a low grade and making notes and calculations any place but the notebook is discouraged. The notebook should contain:

a – Date(s) of performance
b – Procedure followed with the observed results
c – Answers to questions asked on the instruction sheet
d – A table of data obtained if appropriate
e – Sample calculations
f – Names of other students who took part if it is a group project
g – Sketches if appropriate
h – Conclusions

No specific format is required, but the student will be graded on neatness, completeness and accuracy of results. If the student does not obtain the desired result, he can improve his grade by including a section in his report giving possible reasons for his incorrect result.

The notebooks are collected and graded about every ten days.

5. **Homework assignments**

Homework problems are assigned but not collected. Instead, students are selected at random to show their solutions to the class and are given grades for their presentation. Any homework problem which was found difficult by the entire class is explained by the instructor.

6. **Professional attitude**

This is a subjective evaluation on the part of the instructor of those aspects of a student's character which will have a bearing on his ability to perform successfully as a chemical technician.

7. **Class participation**

The student is evaluated for his participation in and contributions to class discussions, answering the instructor's questions, asking pertinent and relevant questions and also by a random evaluation of lecture notes.

Objective:

To differentiate between ionic bonding and covalent bonding as atoms unite to form molecules.

Preparation:

Textbook (chapter 4, pages 76-81) K & E overhead projectuals 7, 18, 19, 20, 21, 22

Introduction:

Why does water consist of two hydrogen atoms and one oxygen atom per molecule? Why not some other combination?

Connection with previous lesson:

Up to this point we have studied individual atoms. We will now determine the properties of atoms which control how they bond to each other to form molecules.

Presentation:

Lecture, Discussion and Illustration using the overhead projectuals.

Teaching points:

1. Electronic rearrangements will give a more stable state at a lower energy level.
2. Molecular orbitals vs. valence-bond.
3. Diatomic hydrogen molecule.
4. Low ionization potential coupled with high electron affinity favors ionic bonding.
5. Electron transfer and valence numbers.
6. "Sharing of electrons" in covalent bonds.
7. Single, Double and Triple bonds.

Classwork:

Write some formulas on the board and have students decide if it is an example of ionic or covalent bonding

Homework:

1. Read pages 81 – 90
2. Problems 1, 9, 11, 18 on page 99 in textbook

GENERAL CHEMISTRY – 101

First Semester (16 Weeks)
Lecture: 5 hours per week
9 hours per week
Credits: 8

This is the first chemistry course of the core program given to incoming Freshmen. It consists of 80 hours of lecture and demonstration (5 hours per week) and 144 hours of laboratory work (9 hours per week) and is an 8-credit course. The final exam (3 hours) is given after the 16th week.

An attempt is made to correlate lectures with lab work, but this is not always possible since there is much to be covered that is of a theoretical nature which does not lend itself to laboratory work. Conversely, there is a large body of knowledge which can best be learned by experimentation without a formal lecture. As the course progresses, the student will find that what he learns in the lectures will help him in doing a better job in the lab, and what he learns by experimentation will help him in understanding the theory that governs what he observes in the lab.

The material covered falls into the following categories:
(1) the nature of matter, (2) atomic structure, (3) chemical changes (4) solutions, (5) kinetics, (6) equilibrium, (7) electrochemistry and (8) laboratory proficiency as it relates to the theoretical objectives. It is necessary for the chemical technician to understand these fundamentals if he expects to work in any field of chemistry, including those dealing with environmental problems.

This first course in the program is designed to provide the chemical technician with some of the skills for handling laboratory apparatus, and some of the knowledge of chemical principles which are prerequisites for more specific and complex courses in quantitative analysis, instrumental analysis, physical chemistry and organic chemistry.

TOPICAL OUTLINE – CH–101

LECTURE		80 HRS.
Section 1	Fundamental Concepts	11
Unit 1.1	Introduction	1
1.1.1	Definition of chemistry and the application of chemical knowledge to the problems of society	
Unit 1.2	Matter, energy, heat, temperature and calorimetry	1
Unit 1.3	Elements, compounds, solutions, symbols and formulas	2
Unit 1.4	Dalton's atomic theory	3
1.4.1	Conservation of mass	
1.4.2	Law of definite composition	
1.4.3	Law of multiple proportions	
Unit 1.5	Atomic weight	2
1.5.1	Isotopes	
1.5.2	Dulong and Petit's Law	
Unit 1.6	Avogadro's number	2
Section 2	Atomic Structure	8
Unit 2.1	Discharge tube experiments	2
2.1.1	Electrons and protons	
2.1.2	Determination of mass and charge	
2.2	The atomic nucleus	2
2.2.1	Atomic number and the neutron	
2.2.2	Nuclear stability	
Unit 2.3	Types of radioactivity	2
2.3.1	Natural and induced radioactivity and half-life	
2.3.2	Positrons and alpha, beta and gamma emissions	
Unit 2.4	Nuclear energy	2
2.4.1	Radiochemistry	
2.4.2	Nuclear fission and fusion	
Section 3	The Quantum Atom	6
Unit 3.1	Periodic Law	2
3.1.1	Period occurrence of similar properties	
3.1.2	Periodic table	
Unit 3.2	Electronic energy levels	3
3.2.1	Line spectra and its connection with the periodic table	
3.2.2	Electronic symbols	
3.2.3	Atomic sizes	
Unit 3.3	Ionization potential and electron affinity	

Section 4	The Molecule	4
Unit 4.1	Electrons in molecules	4
4.1.1	Ionic and covalent bonds	
4.2.2	Polarity of bonds	
4.1.3	Electronegativity	
4.1.4	Saturation of valence	
Section 5	Formulas and Equations	7
Unit 5.1	Nomenclature of compounds	3
5.1.1	Oxidation number of ions	
5.1.2	Simple and molecular formulas	
Unit 5.2	Chemical reactions	4
5.2.1	"No-Electron Transfer" reactions	
5.2.2	Oxidation-reduction reactions	
5.2.3	Balancing chemical equations	
5.2.4	Equivalents	
Section 6	Gases	6
Unit 6.1	Gas Laws	5
6.1.1	Boyle's Law and Charles' Law	
6.1.2	Dalton's law of partial pressures	
6.1.3	Gay-Laussac's law and Avogadro's principle	
6.1.4	Graham's law of diffusion	
6.1.5	Equation of State	
Unit 6.2	Kinetic Theory	1
Section 7	Solids	3
Unit 7.1	Properties of solids	1
Unit 7.2	Types of solids	1
Unit 7.3	Crystalline structure	1
Section 8	Liquids	2
Unit 8.1	Properties of liquids	2
8.1.1	Evaporation and vapor pressure	
Section 9	Changes of State	2
Unit 9.1	Heating and cooling curves	2
9.1.1	Enthalpy	
9.1.2	Phase diagrams and entropy	

CH-101 80 HRS.

Section 10	Solutions	8
Unit 10.1	Properties and types of solutions	1
Unit 10.2	Methods of describing concentration	2
Unit 10.3	Electrolytes and percent dissociation	2
Unit 10.4	Solubility	1
Unit 10.5	Acids, bases and salts	1
Unit 10.6	Stoichiometry and redox reactions	1
Section 11	Chemical Kinetics	5
Unit 11.1	Nature and Concentration of reactants	1
Unit 11.2	Effect of temperature and catalysts	2
Unit 11.3	Collision theory	1
Unit 11.4	Absolute reaction-rate theory	1
Section 12	Chemical Equilibrium	5
Unit 12.1	Mass action	1
Unit 12.2	Equilibrium constant	2
Unit 12.3	Equilibrium changes	2
12.3.1	Concentration, volume and temperature	
Section 13	Aqueous Solutions	8
Unit 13.1	Dissociation, titration and pH	2
Unit 13.2	Buffer solutions	1
Unit 13.3	Hydrolysis	2
Unit 13.4	Amphoterism	2
Unit 13.5	Solubility product	1
Section 14	Electro Chemistry	5
Unit 14.1	Electrical conductivity	1
Unit 14.2	Electrolysis	1
Unit 14.3	Cells and batteries	1
Unit 14.4	Oxidation potentials	1
Unit 14.5	Balancing equations by half reactions	1
Final Examination		3

OBJECTIVES OF CH-101 LECTURES

The student should be able to:

Section 1 Write scientific definitions of terms and words used in the study of elementary chemistry; explain Dalton's atomic theory and to solve problems* using the laws which are derived from the theory.

Unit 1.1: Identify some of the problems facing society today and to be able to intelligently discuss how chemistry and technology in general can help solve these problems.

Unit 1.2:
A. Define in essay form matter and energy and their relationship to each other.
B. State the difference between heat and temperature.
C. Convert temperatures from one scale to another.
D. Solve simple problems in calorimetry.

Unit 1.3:
A. State the differences in writing elements, compounds and solutions and also between heterogeneous and homogeneous matter.
B. Write at least ten of the common elements using their symbols and to be able to differentiate between a number used as a coefficient and one used as a subscript in a chemical formula; when given examples of both.

Unit 1.4: Solve problems* concerning the laws of conservation of mass, definite composition and multiple proportions.

Unit 1.5:
A. Determine that the atomic weights are relative and are based on a reference standard which is the carbon 12 isotope.
B. Write a definition of the word isotope.
C. Solve problems* using Dulong and Petit's laws.

Unit 1.7: Use Avogadro's number in the solution of problems.*

Section 2 Draw a simple diagram of the structure of an atom and describe in writing the nature of the major parts of the nucleus of an atom; list and explain the three most common forms of radioactivity and state the difference between fission and fusion.

Unit 2.1: Write a description of the discharge tube experiments that were performed to determine the nature of an atom.

Unit 2.2:
A. Describe, in written form, the process of transmutation and how its discovery led to the concept of the scale of atomic numbers.
B. Read, interpret and explain orally a graph showing the belt of stability of non-radioactive nuclei.

Unit 2.3:
A. List the forms of emissions from atomic nuclei and how these emissions occur.
B. Draw curves depicting the half-lifes of unstable nuclei.
C. Give a brief written description of how transuranium elements are formed.

Unit 2.4:
A. Write a short essay on the use of tracer techniques to determine the age of an object and the operation of a nuclear reactor to initiate fission.
B. List the steps in the conversion of hydrogen to helium and to calculate the energy released using Einstein's Equation.

Section 3 Correlate the chemical properties of the elements with the periodic table using electron energy levels and determine from a given list which elements are most likely to bond with each other to form molecules.

Unit 3.1:
A. Predict chemical and physical properties of an element from its position on the periodic table.
B. State the difference between a group and a period on the periodic table.

Unit 3.2:
A. Determine the electronic energy levels of an element by its position on the periodic table.
B. Ascertain which electrons contribute to the valence of an element.
C. Explain, in writing, the octet rule.
D. Draw the electronic symbol of the elements in the main groups.

Unit 3.3: Write a statement stating the difference between a positive ion and a negative ion.

Section 4 Account for the aggregation of individual atoms into molecules.

Unit 4.1:
A. State the difference, in writing, between ionic and covalent bonding and between polar and non-polar bonds with the aid of the electro-negativity scale.
B. Draw molecules which show saturation of valence.

Section 5 Calculate the amounts of chemicals needed or the amounts of chemicals produced in a chemical reaction when given formulas and equations.

Unit 5.1:
A. Name twenty of twenty-five compounds when given formulas.
B. Determine the oxidation numbers of elements and ions from a set of given rules.

Unit 5.2:
A. Explain, in written form, the difference between oxidation-reduction reaction and those in which there is no change in oxidation numbers.
B. Balance both types of equations.
C. Use the concept of equivalents in balancing equations.

Section 6 Make calculations using the various laws governing the behavior of gases and explain in a short essay the kinetic theory and its application to gases.

Unit 6.1: A. Define in technical terms volume, temperature and pressure.
B. Make calculations using the laws governing ideal gases.

Unit 6.2: Explain in writing why gases deviate from ideal behavior.

Section 7 List the types of solids and their properties, draw various crystalline structures and write a description of the effect of lattice defects.

Section 8 List the properties of liquids and write a short essay on the colloidal state and the principle of adsorption.

Section 9 Draw heating and cooling curves, explain by examples the concept of enthalpy, draw phase diagrams and give a basic definition to the concept of entropy.

Section 10 Specify, in writing, the concentrations of solutions. List the properties of electrolytes of various types, and make stoichiometric calculations involving solutions.

Unit 10.1: Write a short essay on the properties and types of solutions.

Unit 10.2: Perform calculations involving the various ways of specifying the concentrations of solutions.

Unit 10.3: Give a written definition of an electrolyte including its relative strength based on how much of it is dissociated.

Unit 10.4: A. State the difference, in writing, between unsaturated, saturated and supersaturated solutions.
B. Perform calculations using the solubility product for slightly soluble salts.

Unit 10.5: Write a short essay defining the words acid, base and salt.

Unit 10.6: A. Perform dilution and titration calculations when given three of the four necessary values.
B. Balance oxidation-reduction reactions occurring in both acidic and basic solutions.

Section 11 Make some logical predictions about the rate of chemical reactions when given information about concentrations and temperatures.

Unit 11.1: Formulate a rate law pertaining to temperature changes and to list common catalysts and how they are used.

Unit 11.2: Formulate a series of logical steps for a reaction mechanism and decide which step determines the rate of the reaction.

Unit 11.3: Explain in writing the meaning of the term activation energy and how catalysts affect it.

Section 12 Predict orally or by calculations how an equilibrium system will change when some stress is applied using Le Chatelier's Principle.

Unit 12.1: Set up a mass action expression for a chemical reaction using data from experimentation.

Unit 12.2: Find and/or use the equilibrium constant in mass action expressions for both Homogeneous and Heterogeneous reactions.

Unit 12.3: Write in essay form the effects of changing the equilibrium of a system by concentration, volume, temperature and catalysts.

Section 13 Apply the principles of section 3 to solve equilibrium type problems which occur in aqueous solution.

Unit 13.1: Perform calculations with dissociation constants, pH values and titrations.

Unit 13.2: Explain, either in writing or orally, how buffering a solution can decrease the change in its hydrogen ion concentration.

Unit 13.3: Show by writing equations how water can be considered a reacting species in a chemical process.

Unit 13.4: Show, by writing equations, how certain ions can act as both acids and bases, depending upon what they react with.

Unit 13.5: Write an experimental procedure for determining a solubility product and then show how it is used for predicting if a precipitate will form when concentrations of ions are given.

Section 14 Write an essay which explains the conduction of electrical energy through matter, its conversion into chemical energy by electrolysis and the conversion of chemical energy to electrical energy in devices such as cells and batteries.

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* For problem solving the student will be given the formula with one unknown.

GENERAL CHEMISTRY LABORATORY

Lab Manual: PROPERTIES AND NUMERICAL RELATIONSHIPS OF THE COMMON ELEMENTS AND COMPOUNDS
Belcher, Colbert and Rowley

Preliminary to Lab Work:	Hours
1. Check in of equipment and keys	3
2. Safety procedures	1
3. Proper use of analytical balances	2

Experiment Number	Manual Number	Hrs.	Title Of Experiment
1	1	6	Laboratory Techniques
2	2	4	The Determination of Physical Constants
3	3	4	Substance and their Properties
4	4	4	Chemical Changes
5	5	4	Synthesis of a compound and calculation of formula
6	6	4	Composition of compound and Laws of definite and multiple Proportions
7	7	4	Oxygen
8	10	4	Chemical and Physical Properties of Hydrogen
9	12	4	The Atomic Weight of a Metal
10	13	4	Valence of a Metal
11	14	4	Types of compound Displacement Reactions
12	15	3	Periodic and Family Relationships of Elements
13	16	2	Structure and Properties of Atoms
14	17	4	Chemistry of water
15	18	4	Constitution of Hydrates
16	19	3	Molecular weight of a Gas
17	20	3	Solutions
18	24	3	Basic Oxides: Hydroxide Bases
19	25	3	Hydrogen Chloride
20	28	3	Acids and Acidic Oxides
21	29	3	Salts
22	30	3	Chemical Equilibrium and Reaction Rate
23	22	3	Ionization of Acids, Bases, and Salts
24	23	4	Standard Solutions and Titrations
25	32	3	Acid-Base indicators and their use
26	33	2	Hydrolysis of salts and indicator effects
(G) 27	(I)	3	Solubility product
(G) 28	48	3	Heat of solution of Zinc Chloride
29	31	3	Ionic Equilibrium

Experiment cont'd.

Experiment Number		Manual Number	Hrs.	Title Of Experiment
(G)	30	(I)	3	Viscosity determination
	31	55	3	Soaps and Detergents
	32	57	3	Synthetic dyes and perfumes
(G)	33	44	3	The oxides of Carbon
	34	52	4	The analysis of a sample of coal
(G)	35	40	3	The oxides of Nitrogen
	36	42	3	Phosphorous and its compounds
(G)	37	56	4	Testing the purity of cosmetics and tooth paste
	38	61	3	The alkaline earths and hard water
	39	63	3	Zinc, Cadmium and Mercury
	40	65	3	Tin and Lead

(G) Group experiment

(I) Instructor handout

OBJECTIVES OF LABORATORY EXPERIMENTS

The student should be able to:

Experiment 1: a. Use the bunsen burner and heat objects using the proper techniques.
b. Heat and bend glass tubing properly.
c. Weigh objects with the accuracy expected from a specific balance.
d. Filter and evaporate a solution to dryness in the proper manner.

Experiment 2: a. Determine boiling points and melting points as a means to identification of specific substances.
b. Read a thermometer.
c. Fill a burette and deliver a definite quantity of liquid.

Experiment 3: Identify the properties of some substances and to devise a method of separating a mixture of them into their component parts.

Experiment 4: State the differences among four types of chemical changes after experimentation and observation.

Experiment 5: Synthesize a simple compound and calculate its formula from experimental data.

Experiment 6: a. Verify the laws of definite and multiple proportion from the data obtained from the decomposition of two different compounds.
b. Determine that a catalyst increases the rate of a reaction, but has no effect on the amount of product formed.

Experiment 7: a. Prepare oxygen from decomposition of an oxygen-containing compound.
b. Detect the presence of oxygen.
c. Determine some of its properties.

Experiment 8: a. Prepare hydrogen by the action of a metal on an acid.
b. Detect the presence of hydrogen.
c. Determine some of its properties.

Experiment 9: Determine the approximate atomic weight of a metal by calorimetric methods and then, using other given information, calculate the exact atomic weight.

Experiment 10: a. Determine the equivalent weight of a metal from the measured volume of hydrogen displaced when a known weight of the metal reacts with excess acid, and to calculate the valence of the metal, given the atomic weight.
b. Collect gases by the water displacement method which applies to any gas that has negligible solubility in water and does not react with it.

Experiment 11: Determine which types of chemical compounds will function in displacement reactions, and determine if heating has any effect on the rate of the reaction.

Experiment 12: List the changes in chemical and physical properties of the elements in the main groups of the periodic table by observing the reactions of a representative element of each group.

Experiment 13:
a. Conclude that when some atoms are excited by high temperatures colors are emitted.
b. Fill in a chart which lists the electrons in the main shells and the subshells.
c. Determine the changes in size of atoms when they combine. When given pairs of elements list whether they form ionic or covalent bonds.

Experiment 14:
a. Determine some of the properties of water and some of the ways that water can be purified.
b. Demonstrate that the addition of water to certain salts can affect their acidity (hydroysis).
c. Determine that some salts accept water molecules into their own molecular structure (hydration).

Experiment 15: Prepare, determine the formula, and list the properties of a hydrate.

Experiment 16: Determine the molecular weight of oxygen by the vapor density method which can be applied to any gas which has a negligible solubility in water.

Experiment 17:
a. Determine some of the factors affecting solubility:
    (1) choice of solvent
    (2) surface area of solute
b. List some of the properties of solutions:
    (1) volume changes
    (2) temperature changes
c. Differentiate between unsaturated, saturated and super saturated solutions.

Experiment 18: Prepare some soluble basic oxides and, by testing them, list their properties in aqueous solution.

Experiment 19: Prepare hydrogen chloride gas and list its properties.

Experiment 20: Prepare binary acids and oxyacids and list their properties.

Experiment 21: Prepare salts by eight different methods and list their properties.

Experiment 22: Classify reactions as reversible and non-reversible and determine the effect of temperature and concentration changes on the rate of a chemical reaction.

Experiment 23: Determine the extent to which certain acids, bases and salts ionize in aqueous solution and the effect of dilution on conductivity.

Experiment 24: Standardize a solution of sodium hydroxide and then use it to determine the concentration of acid in a sample of vinegar.

Experiment 25: a. Compare by observation the relative strengths of acids and bases of the same normality by the use of indicators.
b. Determine an approximate pH by the use of indicators.
c. Discover the effect of buffers on solutions of weak acids and bases.

Experiment 26: Decide on the best indicator to use for a specific titration after writing the hydrolysis equation and confirming it by experimentation.

Experiment 27: Find the solubility product of an unknown salt by experimentation and then compare the value obtained with published values when the identity of the salt is made known.

Experiment 28: Find the heat of solution of a salt by calorimetry experiments and then compare the value obtained with published values.

Experiment 29: Answer the question "why did it happen?" for nine separate experiments in which the point of equilibrium is shifted in a chemical reaction.

Experiment 30: Operate correctly a viscometer of the ostwald type. He should be able to make accurate readings both at room temperature and over a temperature range for various liquids, choose the proper tube for a specific liquid, and compare and interpret his results with published values.

Experiment 31: a. Prepare a simple soap and test it along with any commercial soap for alkalinity, emulsification, cleansing action and excess glycerin.
b. Compare the detergents with soap for the properties in "A", determine the relative amounts of phosphorous in the detergents and compare results with published values.

Experiment 32: a. Synthesize two typical dyes, and use them along with others to determine if they are fast or not, if they need mordants, if they are good for all types of fabrics and if there are any disposal problems which would have to be overcome if work was done on a large scale.
b. Synthesize a simple perfume.

Experiment 33: a. Prepare carbon dioxide and determine some of its properties.
b. Prepare carbon monoxide and determine some of its properties in a safe manner.
c. Test for the presence of carbon in an organic substance.

Experiment 34: Quantitatively analyze a sample of coal for moisture, other volatile matter, fixed carbon and mineral matter which becomes the ash.

Experiment 35: Prepare some oxides of Nitrogen and determine some of their properties with special emphasis on their effect on the environment.

Experiment 36: Test a sample for the presence of phosphorous and determine some of the properties of the element and some of its compounds with special emphasis on their effect on the environment.

Experiment 37: Test various toilet preparations for the presence of ingredients prejudicial to health, and as a result to make a more intelligent selection of these products.

Experiment 38: Test for the presence of the alkaline earth metals, determine the causes of hardness in water, its amount, and methods of softening the water.

Experiment 39: Test for the presence of Zinc, Cadmium and Mercury in solution and determine some of the properties of these elements with special emphasis on their effects on the environment.

Experiment 40: a. Test for the presence of Tin and Lead and determine some of the properties of these elements with special emphasis on their effects on the environment.

b. Separate a sample of solder into its two components, Tin and Lead.

Certain objectives should be listed under all of these experiments. These are:

(1) Write balanced equations for the reactions taking place.
(2) Dispense chemicals from their containers in a safe and careful manner.
(3) Use all equipment in such a way that the work will be safely performed and that the most accurate results will be obtained.
(4) Keep all equipment scrupulously clean.
(5) Follow directions carefully.
(6) Keep very thorough and accurate results in the notebook.
(7) Develop some degree of confidence in laboratory techniques and reliance on individual judgement in decision making.

In a typical week in this course one-half period is spent on a short lecture as a review for a previously learned concept and the other two and one-half periods are spent as problem solving sessions. The instructor will demonstrate the solution of one or more typical problems and then circulate through the room, aiding individual students in solving problems.

TEXTBOOKS

The textbooks for Chemistry 105 are:

1. *Chemical Calculations,* H. V. Anderson, Sixth Edition, McGraw Hill, New York, N. Y. 1955
2. *College Chemistry*, D. Schaum's Outline Series, McGraw Hill, New York, N. Y., 1972

EVALUATION OF STUDENTS – CH 105

The students are evaluated on their test results, homework assignments, professional attitude and class participation as follows:

Test results	40%
Final exam	25%
Homework	15%
Class participation	10%
Professional attitude	10%
	100%

A composite grade of 70% would be necessary for a student to receive a letter grade of "C".

1. Tests:

Five tests, including the final examination, are given during the course at the times specified. The tests will concentrate upon presenting an opportunity for a student to display mastery of the behavioral objectives. In some instances the tests will consist of performing a laboratory problem. Unannounced quizzes may be given at any time. A quiz may be anything from a single problem taking 10 minutes up to what might be considered an extra test. For grading purposes, a quiz counts half as much as a test, since the student has not specifically prepared for it. After the second test, each student is individually counseled concerning his progress to that point. His performance is discussed and if improvement is required he is informed of his deficient areas and what is expected of him in order to receive at least a "C" grade for the course. For the students who are not making much progress, counseling is necessary before this point. Tests and quizzes are devised in such a way as to reflect the attainment of the objectives of the course. A student who averages 90 or better will get an "A" for the course. A grade of 75 to 90 would be in the "C" to "B" range. A student scoring between 60 to 75 needs extra help before continuing and one who scores less than 60 is in serious danger of failing the course.

Written tests will be given after the following points in the outline:

Test # 1 After Section 3	1 hour
Test # 2 After Section 6	1 hour
Test # 3 After Section 9	1 hour
Test # 4 After Section 12	1 hour
FINAL EXAMINATION	1½ hours

2. **Homework assignments:**

Homework problems are assigned but not collected. A random survey is made to determine if the homework has been attempted by the student. Students are selected to show their solutions to the class and are given grades for their presentation. Any homework problem which was found difficult by the entire class is explained by the instructor.

3. **Class participation:**

The student is evaluated for his participation in and contributions to class discussions, answering the instructor's questions and also by a random evaluation of lecture notes.

4. **Professional attitude:**

This is a subjective evaluation on the part of the instructor of those aspects of a student's character which will have a bearing on his ability to perform successfully as a chemical technician in industry.

Objective:

To solve temperature conversion problems using the absolute (kelvin) temperature scale.

Preparation:

Reading assignment pages 52-57 in textbook. Overhead projectuals on Charles' Law.

Introduction:

How low can the temperature go? When does the volume theoretically become zero?

Connection with Previous Lesson:

We have studied the development of the Fahrenheit and Centigrade temperature scales. Now we will discuss the lowest temperatures that can be reached on these scales.

Presentation:

Lecture with overhead projectuals. Blackboard for problem solving.

Teaching Points:

1. Review Fahrenheit and Centigrade scales.
2. Contraction of volume of a gas by 1/273 for every degree Centigrade.
3. Connection with Charles' Law
4. The Rankine scale

Classwork:

Problems 1, 3, 4, 5, 7 from text on page 57

Homework:

Problems 10, 12, 14, 16, 18, 21, 23, 25, 28, 30 from text on pages 57 and 58.

CHEMICAL CALCULATIONS CH–105

First Semester (16 weeks)
Lecture: 3 hours per week
Credits: 3

Chemical Calculations is a first semester course in a two-year program in chemical and environmental technology. The class meets for 16 weeks. The final exam is given after the 16th week. It is a three credit course requiring 48 hours of class lecture.

It is designed primarily as a problem solving course to apply the fundamental principles of general chemistry. In the General Chemistry course, some problems are solved to illustrate a principle or concept, but a course of this nature is necessary for further elucidation by the instructor, since many students are found to be deficient in their mathematical preparation.

There must be close cooperation between the instructor of this course and the instructor of the General Chemistry course, so that these problem solving sessions run as concurrently as possible with the theoretical presentations in the core course.

TOPICAL OUTLINE CH–105

LECTURE		48 HRS.
Section 1	Measures and weights	3
Unit 1.1	Metric system	
Unit 1.2	Significant figures	
Unit 1.3	Dimensional units	
Section 2	Density	3
Unit 2.1	Specific gravity of solids	
Unit 2.2	Specific gravity of liquids	
Unit 2.3	Percentage concentration	
Section 3	The Measurement of Temperature	3
Unit 3.1	Thermometric scales	
Unit 3.2	Absolute zero	
Unit 3.3	Absolute temperature	
Section 4.	The Language of Chemistry	4
Unit 4.1	Valence and formula writing	
Unit 4.2	Rules of chemical nomenclature	
Unit 4.3	Percentage composition	
Section 5	Gram-atom and gram-mole	3
Unit 5.1	Gram-atomic weight	
Unit 5.2	Gram-molecular weight	
Unit 5.3	Other weight units	
Section 6	Derivation of chemical formulas	3
Unit 6.1	Empirical formulas	
Unit 6.2	Molecular formulas	
Unit 6.3	Formulas of hydrated compounds	
Section 7	Chemical equations – nonredox	3
Unit 7.1	Balancing of equations	
Unit 7.2	Equation writing	
Unit 7.3	Relations between mol-weight and gas-volume	
Section 8	Oxidation – Reduction	3
Unit 8.1	Oxidation numbers	
Unit 8.2	Balancing redox equations	
Unit 8.3	Ionic redox equations	
Section 9	Gram-equivalent weight	3
Unit 9.1	Elements	
Unit 9.2	Compounds	
Unit 9.3	Gram-equivalent volume	

CH – 105		HOURS
Section 10	Gas Laws	4
Unit 10.1	Boyle's law	
Unit 10.2	Charles' law	
Unit 10.3	Dalton's law of partial pressures	
Section 11	Mole-weight, Gas-volume Relations	3
Unit 11.1	Gay-Lussac's law	
Unit 11.2	Molecular weight from density	
Unit 11.3	Melting point and boiling point determinations	
Section 12	Concentration of Solutions	4
Unit 12.1	Molarity	
Unit 12.2	Normality	
Unit 12.3	Other methods	
Section 13	Principle of Equivalency	3
Unit 13.1	Standardization of solutions	
Unit 13.2	Dilution	
Unit 13.3	Redoximetry	
Section 14	Chemical Equilibrium	3
Unit 14.1	Law of mass action	
Unit 14.2	pH values	
Unit 14.3	Solubility product	
Section 15	Electrochemistry	3
Unit 15.1	Electrochemical series	
Unit 15.2	Laws and units of electricity	
Unit 15.3	Electrolysis	

Final Examination

OBJECTIVES OF CH–105

The student will be able to solve problems of the following nature:

Section 1: Length, weight, and volume conversions within the metric system and between the English and metric systems, using dimensional analysis and stating the answers in the correct number of significant figures.

Section 2: A. Calculate densities from given weight and volume information and calculate weight and/or volume from given densities.

B. Calculate any of the three units from percentage by weight information of solutions.

Section 3: Make conversions from and to all four temperature scales.

Section 4: A. Write symbols and formulas from names of chemical elements and compounds and to write the names from the symbols and formulas.

B. Calculate the percentage of an element in a given chemical compound.

Section 5: A. Determine the number of gram-atoms of an element in a given weight of the element.

B. Determine the number of gram-moles of a compound in a given weight of the element.

Section 6: A. Derive the simplest formula from a percentage composition.

B. Derive a molecular formula of a gas from percentage composition and density.

C. Calculate a molecular formula of a hydrated compound from a percentage composition.

Section 7: A. Given the chemical formulas of the reactants and products, balance the equation.

B. Predict the products of a chemical reaction and then balance the equation.

C. Calculate the molar and weight relations in a balanced reaction.

Section 8: A. Determine the oxidation number of each element in a chemical formula.

B. Determine the electron transfers in a redox equation.

C. Balance redox equations by the electron-transfer method.

D. Calculate the molar and weight relations in a balanced redox equation.

Section 9: A. Determine the number of grams in a gram-equivalent of an element or a compound.

B. Determine the gram-equivalent weights of elements and compounds.

C. Determine the gram-equivalent weights of acids and bases.

Section 10: A. Determine volumes, pressures and temperatures of gases using Boyle's and Charles' laws.

B. Calculate volumes of gases at standard temperature and pressure (STP)

C. Calculate the effect of temperature and pressure changes on the density of a gas.

D. Calculate the volumes of gases collected over water using Dalton's Law and the vapor pressure of water.

Section 11: A. Calculate the number of moles and number of grams of a gas when given the volume of the gas.

B. Calculate the molecular weights of gases from their densities.

C. Calculate the molecular weight of a volatile liquid from its weight and its displacement of air over water.

D. Determine the molecular weight of a non-electrolyte by freezing point lowering and boiling point elevation methods.

Section 12: A. Determine the number of moles in a solution and its molarity.

B. Calculate molarities of solutions after dilution.

C. Determine the number of gram-equivalents in a solution and its normality.

D. Calculate normalities of solutions after dilution.

Section 13: A. Determine the exact normality of a solution for standardization purposes.

B. Calculate the amount of one solution to exactly react with a known amount of another solution.

C. Determine normalities of redox reagent solutions in chemical reactions.

Section 14: A. Calculate the concentrations of ions in solutions of weak electrolytes.

B. Calculate pH values from hydrogen or hydroxyl ion concentrations.

C. Calculate solubility products from solubility information.

D. Determine the minimum concentration of an ion necessary to bring about precipitation.

Section 15: A. Determine the electrochemical equivalents of elements and the amounts that will be liberated from their solutions by an electrical current.

B. Calculate the amount of current produced in various electrochemical cells.

C. Express number of coulombs in terms of number of faradays.

The course is taught as a combination of lecture and laboratory experiments. The lectures cover, in more depth, many of the principles and concepts of general chemistry which are necessary for solving the problems of analytical chemistry. Skills and techniques to be learned in this course are largely refinements of those from the first quarter. Some new skills are added with the emphasis on the attainment of precision and accuracy in laboratory work.

The laboratory experiments are of the type where a sample is issued to a student and he is required to determine the amount of some ingredient within specified limits. They are performed on an individual basis.

Demonstrations to the entire class are given when appropriate, but more often the instructor will demonstrate a proper technique to an individual student who may be having difficulty. Close supervision of the students' work is necessary both for reasons of safety and for the development of proper techniques.

TEXTBOOKS

The textbook for Chemistry 102 is:

1. *A Short Course in Quantitative Analysis,* Willard, Furman and Bacon, Second Edition, D. Van Nostrand Co., Princeton, New Jersey, 1966

EVALUATION OF STUDENTS (CH–102)

The students are evaluated on their test results, laboratory performance, laboratory proficiency, laboratory notebook homework assignments, professional attitude and class participation. A composite grade of 70% would be necessary for them to receive a letter grade of "C" for the course.

1. Tests:

Seven tests, including the final examination, are given during the course at the times specified. In some cases, tests will consist of laboratory problems. In all instances the tests are based upon the stated Behavioral Objectives. Unannounced quizzes may be given at any time. A quiz could be anything from a single problem or essay taking 10 minutes up to what might be considered an extra test. After the fourth test each student is individually counseled concerning his progress to that point. His performance is discussed and if improvement is required he is informed of his deficient areas and what is expected of him in order to receive at least a "C" grade for the course. For students who are not making much progress, counseling is necessary before this point. Tests and quizzes are devised in such a way as to reflect the attainment of the objectives of the course. A student who averages 90 or better will get an "A" for the course. A grade of 75 to 90 will be in the "C" to "B" range. A student scoring between 60 to 75 needs extra help before continuing and one who scores less than 60 is in serious danger of failing the course.

Written tests will be given after the following points in the outline.

Test # 1: Section 1	1 hour
Test # 2: Section 2	1 hour
Test # 3: Section 3	1 hour
Test # 4: Section 4	1 hour
Test # 5: Section 5	1 hour
Test # 6: Section 6	1 hour
FINAL EXAMINATION	3 hours

2. Laboratory Performance:

A rating sheet for laboratory performance is included as an appendix. It is filled out at least twice during the quarter for each student and more frequently if there is any observable improvement or deterioration in a student's performance. If a student gets 125 or better out of a maximum 155 points, he is doing an excellent job in the lab. A score of 100 to 125 indicates that there are some areas that need improvement. When the score is below 100, the instructor should give the student individual counseling to discuss his chances of passing the course.

3. **Laboratory Proficiency:**

Manual ability is evaluated by observation of such operations as:

- a. Making measurements: For volumes this includes filling and partially emptying volumetrically calibrated equipment like cylinders and burets, reading the bottom of the meniscus accurately and choosing the proper size container for the volume to be measured. For weights this includes choosing the proper balance for the job, adjusting it to its zero position, and using the balance gently to avoid sudden jars to its delicate mechanism.
- b. Filtering: Proper folding of the filter paper, pouring into the funnel to prevent overflow and placing the funnel stem on the inside of the collection beaker are points to be observed.
- c. Washing glassware thoroughly so that possible contamination can be avoided.
- d. Heating a partially filled test tube in the flame properly: To avoid having the contents suddenly shoot out of the tube.
- e. Transferring chemicals from one container to another: To avoid contamination. Special emphasis is placed on observing the dispensing of small amounts of liquids with medicine droppers.
- f. Proper heating of a crucible.
- g. Setting up apparatus according to instructions: special care is needed with glass bends, which if they are made too narrow, can cause safety hazards. Another important point to observe is that the student has not created a closed system.
- h. In general: Observations are made as to how well the student follows instructions. The student will also be questioned frequently to evaluate his ability to relate theory to practice in the laboratory. It should be noted that all aspects of laboratory proficiency will be more critically evaluated in the second semester.

4. **Laboratory Notebook:**

The notebook is a record of the students' work in the lab and should be kept up to date. It should contain all notes and calculations for the day the experiment was performed. A delay between performance and recording usually results in a low grade and making notes and calculations any place but the notebook is discouraged. The notebook should contain:

- a. Dates of performance
- b. Procedures followed with observed results
- c. Answers to questions asked on the instruction sheet
- d. A table of data obtained, when appropriate
- e. Sample calculations
- f. Names of other students who took part if it is a group project
- g. Sketches when appropriate
- h. Conclusions

In this course the most important part of the notebook is the answer obtained for the analysis of the unknown samples. Both accuracy and precision are evaluated.

No specific format is required, but the student will be graded on neatness, completeness and accuracy of results. If the student does not get the desired result, he can improve his grade by including a section in his report giving possible reasons for his incorrect result.

The notebooks are collected and graded about every ten days.

5. **Homework Assignments:**

Homework problems are assigned but not collected. Instead, students are selected at random to show their solutions to the class and are given grades for their presentation. Any homwork problem which was found difficult by the entire class is explained by the instructor.

6. **Professional Attitude:**

This is a subjective evaluation on the part of the instructor of those aspects of a student's character which will have a bearing on his ability to perform successfully as a chemical technician in industry.

7. **Class Participation:**

The student is evaluated for his participation in and contributions to class discussions, answering the instructor's questions, asking pertinent and relevant questions and also by a random evaluation of lecture notes.

LESSON PLAN CH–102 **Section 2, Unit 2.3**

Title: Methods of Expressing Solution Concentration

Objective:

To perform calculations involving the various ways of specifying the concentrations of solutions.

Preparation:

1. Textbook (Chapter 4, pages 38-42)
2. K.E. overhead projectuals 40 and 41

Introduction:

To fix the properties of a solution it is necessary to specify the concentrations of its components. In many cases, the concentration of a solution must be known in order to write a correct equation for a reaction.

Connection with previous lesson:

The various types of solutions have been discussed and the words molarity, normality and molality have been defined. With this as a background, the ways that the concentration of a solution can be expressed can now be discussed.

Presentation:

Lecture, discussion, sample problems, and illustration using the overhead projectuals.

Teaching Points:

(1) Percentage of solute by weight or volume
(2) Molarity
(3) Molality
(4) Normality
(5) Formality
(6) Conversions from one method to another

Classwork:

Problems 1, 2, 3 on page 42 of the textbook

Homework:

Problems 6, 7, 8, 11, 13, 14, 15, 16, 19, 20, 21, 24 through 28 on pages 42 and 43 of the textbook

QUANTITATIVE ANALYSIS CH–102

Second Semester		(16 Weeks)
	Lecture:	4 hours per week
	Laboratory:	6 hours per week
	Credits:	6

Quantitative Analysis is the second semester chemistry course in the core program. It consists of 64 hours of lecture and demonstration (4 hours per week) and 96 hours of laboratory work (6 hours per week) and is a 6 credit course. The final exam (3 hours) is given after the 16th week.

The course builds on the fundamentals of the General Chemistry course and the Chemical Calculations course to provide the student with the necessary skills to follow an analytical procedure, to use the analytical equipment efficiently for precise and accurate work, and to evaluate the derived data.

The lectures are intended to provide the theory necessary for an understanding of the laboratory work. Much of the lecture time is used for solving analytical problems of a practical nature. A good portion of the lecture time, especially in the early weeks of the course, is used for demonstrating the proper use of analytical equipment.

In the General Chemistry Laboratory, the experiments, for the most part, are designed to illustrate various principles. In Quantitative Analysis many of the principles are put into practice. The student is issued a numbered vial containing a few grams of some substance and must make a determination on the amount of some chemical species in the substance with a reasonable degree of accuracy.

TOPICAL OUTLINE

LECTURE		64 HRS.
Section 1.	Introduction	7
Unit 1.1	Importance of analytical chemistry	1
Unit 1.2	Methods of analytical chemistry	1
Unit 1.3	Laboratory equipment and materials	2
Unit 1.4	Laboratory operations	2
Unit 1.5	Rules in weighing	1
Section 2.	Measurement by Volume	10
Unit 2.1	Types of volumetric apparatus	2
Unit 2.2	Calibration of volumetric apparatus	3
Unit 2.3	Methods of expressing solution concentration	2
Unit 2.4	Calculations in volume measurements	3
Section 3.	Evaluation of Quantitative Data	8
Unit 3.1	Accuracy and precision	1
Unit 3.2	Errors and deviations	4
Unit 3.3	Significant figures	3
Section 4.	Acid and Base Titrations	10
Unit 4.1	Indicators	2
Unit 4.2	Titration curves	2
Unit 4.3	Buffers	2
Unit 4.4	Calculating points on titration curves	4
Section 5.	Oxidation Reduction Principles	10
Unit 5.1	Balancing equations	4
Unit 5.2	Potentials	2
Unit 5.3	Redox indicators	2
Unit 5.4	Redox agents	2
Section 6.	Gravimetric Analysis	11
Unit 6.1	Solubility of a precipitate	1
Unit 6.2	Purity of precipitates	2
Unit 6.3	Separations	2
Unit 6.4	Laboratory operations	2
Unit 6.5	Calculations	4
Section 7.	Analysis by Physical Measurements	8
Unit 7.1	Colorimetric methods	4
Unit 7.2	Potentiometric methods	4

OBJECTIVES OF CH–102 LECTURES

The student should be able to:

Section 1	Write a short essay on the importance of analytical chemistry, list some of the pieces of equipment and describe how they are used in analytical chemistry.
Unit 1.1	List five ways chemical analyses are used to aid us in our daily lives.
Unit 1.2	Differentiate between gravimetric and volumetric analyses and give an example of each method
Unit 1.3	Describe, in a few sentences for each, the use of a dessicator, filtering crucible, weighing bottle and vacuum flask.
Unit 1.4	Demonstrate the proper way to transfer liquids and solids, to filter both by gravity and vacuum, and to heat crucibles.
Unit 1.5	List the 8 rules followed when using the analytical balance correctly.
Section 2	List the three major types of volumetric apparatus, demonstrate their proper use, describe how they are calibrated and perform the basic calculations involved in volume measurements.
Unit 2.1	Demonstrate the proper use of burets, pipets and volumetric flasks.
Unit 2.2	Describe, orally, how volumetric apparatus are calibrated.
Unit 2.3	List the four common ways of expressing the concentration of solutions giving an example of each.
Unit 2.4	Perform calculations such as determining equivalent weights, converting concentrations from one system to another and determining the normality of solutions used in titrations and dilutions.
Section 3	Obtain, with measuring devices, scientific facts which may be expressed mathematically in suitable units to convey a degree of accuracy consistent with the conditions under which the facts are obtained.
Unit 3.1	Give written examples of the difference between accuracy and precision.
Unit 3.2	A. List four errors in measurement that are of a random nature and four that are of a systematic nature and describe how each may be corrected. B. Analyze deviations in measurements to decide whether the data should be rejected or retained. Perform calculations using the number of significant figures consistent with the precision of measurement.

Section 4	Construct titration curves from data, select an indicator for a titration and explain, in writing, the action of a buffer solution.
Unit 4.1	Write an explanation of why a given indicator is used for pH determination including the relevant equations.
Unit 4.2	Select an appropriate indicator, based on the titration curve and give written definitions of the terms end point and equivalence point.
Unit 4.3	Explain, in writing, buffering action in terms of the principles of equilibrium.
Unit 4.4	Construct a titration curve from experimental data.
Section 5	Balance redox equations by the oxidation number method and by the half-reaction method, draw a sketch of a Daniell cell for a typical reaction, list three important redox indicators and their uses and list oxidizing agents and reducing agents with their relative strengths.
Unit 5.1	Balance five redox equations by the oxidation number method and five by the half-reaction method.
Unit 5.2	Draw a Daniell cell for a typical redox reaction and calculate the standard potential for the reaction.
Unit 5.3	Supply the indicator for three redox titrations.
Unit 5.4	Set up procedure for the titration of a common oxidizing or reducing agent.
Section 6	A. Write a short essay about the manufacture of a slightly soluble salt and the theoretical factors involved in ensuring its purity. B. Answer correctly ten questions on the laboratory operations used to ensure the maximum amount of a pure precipitate.
Unit 6.1	Calculate the solubility product from given data and calculate the solubility from the solubility product.
Unit 6.2	Correctly answer ten questions dealing with the factors that determine the purity of a precipitate.
Unit 6.3	Demonstrate separation methods such as pH control, formation of complexes, and extraction.
Unit 6.4	Demonstrate the proper methods of washing precipitates, drying precipitates, and ignition.
Unit 6.5	Derive gravimetric factors from analytical data to simplify calculations.

Section 7 A. Write a short essay on the fundamental laws of optics and chemistry underlying colorimeter construction.

B. Write a short essay on the operation of a pH motor.

Unit 7.1 Define the terms absorbance, transmission, Beer's Law, wave length, frequency, refraction and describe how each of these is important in the operation of a colorimeter.

Unit 7.2 Demonstrate the use of a pH meter in an acid-base titration.

QUANTITATIVE ANALYSIS LABORATORY EXPERIMENTS

Preliminaries to Lab Work		Hours
1	Check in of equipment and keys	3
2.	Safety procedures	1
3.	Discussion of laboratory procedures and notebook instructions	2

Experiment Title	Page Numbers	Hours
1. Determination of the percentage of a weak acid (potassium acid phthallate)	52–60	6
2. Titration of an unknown chloride sample by Fajan's method	134–138	9
3. Determination of chloride by precipitation with silver nitrate	160–163	9
4. Determination of iron in an iron ore sample by a redox titration with dichromate	93–101	9
5. Determination of sulfate in a soluble sample by precipitation with barium chloride	163–167	9
6. Analysis of Limestone	175–184	12
7. Analysis of Brass	184–192	12
8. Colorometric determination of permanganate and dichromate ions	199–202	12
9. Acid-base titrations with a pH meter	202–204	12

OBJECTIVES OF CH-102 LABORATORY EXPERIMENTS

The student will be able to:

Experiment 1. Standardize an acid and a base with a primary standard, demonstrate the proper use of a buret, determine the end point in a titration by the indicator color change, determine the normality of a weak acid and ultimately to determine the percent of potassium hydrogen phthalate in an unknown sample within three parts per thousand.

Experiment 2. Prepare a standard solution of silver nitrate, titrate a sample using an adsorption indicator and determine the percent of chloride ion in an unknown sample within three parts per thousand.

Experiment 3. Prepare filtering crucibles; demonstrate that a precipitation is complete; demonstrate proper techniques in heating a solution, stirring, and vacuum filtering; and to determine the percent of chloride ion in an unknown sample by a gravimetric method within three parts per thousand.

Experiment 4. Dissolve and safely heat a sample of iron ore in hydrochloric acid without loss; reduce the ferric ion to ferrous ion; oxidize the excess stannous ion and titrate with potassium dichromate solution in acid medium to determine the percent iron in an unknown sample of iron oxide or iron ore.

Experiment 5. Transfer a precipitate to filter paper with a minimum of loss; demonstrate the proper techniques for ignition of the filter paper in a crucible and determine the percent sulfur in an unknown sample within six parts per thousand.

Experiment 6. Determine loss on ignition in a muffle furnace, filter a gelatinous precipitate, wash a precipitate with an electrolytic solution; determine the percent of calcium and magnesium as their oxides in an unknown sample of limestone within five parts per thousand.

Experiment 7. Dissolve a sample of brass in concentrated nitric acid; filter with a double filter to determine the percent of tin in an unknown sample of brass within five parts per thousand.

Adjust the pH of a solution to approximate neutrality; titrate the tri-iodide ion produced upon addition of excess potassium iodide to the solution with a standard thiosulfate solution to determine the percent of copper in an unknown sample of brass within three parts per thousand.

Experiment 8. Prepare calibration curves for permanganate ion and dichromate ion with a colorimeter to determine the percent of chromium and/or manganese in an unknown sample of steel.

Experiment 9. Tabulate results on a chart after determining the pH at which the various common indicators change their colors for different combinations of strong and weak acids and bases.

These nine experiments have been carefully chosen to cover as many of the different techniques as possible that are commonly encountered in an industrial chemical laboratory. The foregoing objectives only include those which are performed for the first time in a particular experiment. The same technique may be used in succeeding experiments.

Some overall objectives include:

1. Uses proper weighing techniques on the analytical balance.
2. Properly dries samples to drive off any water which adds to the weight of the sample and causes incorrect results.
3. Performs the calculations for each experiment with emphasis on dimensional analysis.

The course is taught using a combination of lectures, demonstrations and laboratory experiments. The lectures, which deal with the chemical aspects of environmental problems, are of an informal nature. The student is encouraged to participate by asking questions and by explaining to the class his solutions of problems. Reading material is assigned to prepare the student for the lectures and problems. Other assignments such as library research are made to reinforce or add to the original lecture.

The textbooks, references and periodicals listed in this syllabus are available either in the lab, from the instructor, or from the school library. It may sometimes be necessary to prepare "Information Sheets" if it is felt that the text does not cover the subject sufficiently.

Guest lecturers are invited to lend expertise on particular subjects. Films and slides are shown where they are deemed appropriate and are available. Charts, graphs, pictures and cartoons can and should be collected and used as needed during the presentation of the lectures. The overhead projector is also used.

Demonstrations to the entire class are given as appropriate and laboratory work is performed on a group basis. Close supervision of the student's work is necessary both for reasons of safety and for the development of proper techniques.

TEXTBOOKS

The textbook for Chemistry 106 is:

1. *Environmental Chemistry*, H.S. Stoker and S.L. Seager, First Edition, Scott, Foresman and Co., 1972

EVALUATION OF STUDENTS CH–106

The students are evaluated on the following criteria:

Test results (3)	25%
Weekly essays (13)	35%
Class participation & Laboratory performance	15%
Final exam	25%
	100%

A composite grade of 70% is necessary to receive a letter grade of "C" for the course.

1. **Tests:**

Three hour-long tests are given during the course at the times specified. After the second test, which is at mid-term, each student is individually counseled concerning his progress to that point. His performance is discussed and if improvement is required he is informed of his deficient areas and what is expected of him in order to receive at least a "C" grade for the course. For the student who is not making much progress, counseling is necessary before the mid-term. Tests are devised in such a way as to reflect the attainment of the objectives of the course. A student who averages 90 or better will get an "A" for the course. A grade of 75 to 90 would be in the "C" to "B" range. A student scoring between 60 and 75 needs extra help before continuing and one who scores less than 60 is in serious danger of failing the course.

Written tests will be given after the following points in the outline:

Test # 1	Section 3
Test # 2	Section 7
Test # 3	Section 11

Final examination given during 16th week.

2. **Weekly Essays:**

Thirteen essays are required during the course. The student should divide his essay into two parts. The first should be a summary in his own words of the material that was covered in class. The objective is to add a summary to the end of a study unit, similar to those found at the ends of chapters in many textbooks. The second part should include something he has learned outside the classroom. The source could be library research, periodicals (both science oriented and non-science oriented), or his own personal experiences.

The instructor will prepare a list of items which should appear in the student summary. The student's paper will be evaluated on 1) his ability to summarize the pertinent material 2) the value and quality of his own contribution and 3) the neatness, clarity and construction of the paper. A single-spaced typewritten page will be considered as the minimum length of these essays.

There are no other homework assignments in this course since the essays serve the same purpose. The writing of the summary meets two objectives of homework. The material must be studied and reviewed, and the finished summary can be used as a study guide for tests. Writing about some topic not covered in class encourages researching the literature which is one of the objectives of this course.

Class participation and Laboratory Performance:

The student is evaluated for his participation in and contributions to class discussions, answering the instructor's questions, asking pertinent and relevant questions and also by a random evaluation of his lecture notes.

The student will be evaluated in the laboratory by observing:

1 – Manual ability
2 – Careful use of delicate instrumentation
3 – Safe use of chemicals and equipment
4 – Regard for safety regulations
5 – Collecting of data
6 – Amount of effort
7 – Scientific attitude

In general, observations are made as to how well the student follows instructions. The student will also be questioned frequently to evaluate his ability to relate theory to practice in the laboratory.

Objective:

To explain how lead gets into the body and its toxicologic effects.

Preparation:

Reading Assignment: pages 137–140 in the text.

Introduction:

Ask the students how many of them use low-lead or non-leaded gasolines. Since the lecture today centers on lead poisoning the question at the end of the lecture will be how many of them plan to use these gasolines after today.

Connection with Previous Lesson:

The previous lesson was on the sources of lead pollution. Today's leasson is on the effects of that pollution and tomorrow's will be on the methods of preventing and controlling it.

Presentation:

Lecture and discussion, graphs and charts and demonstration of determination of concentration of lead in the urine.

Teaching Points

1. Review previous lesson on the sources of lead pollution.
2. The ways that lead gets into our food.
   a. Acidic soil
   b. Lead pigment in paints
   c. Buckshot in fowl
   d. Lead containing ceramic glasses on foodstuff containers
   e. Lead solder used in "moonshine stills".
3 The effect of lead in the body.
   a. Inhalation, ingestion and absorption
   b. Toxic action
   c. Biological half-life
   d. Blood and urine tests
   e. Bone tests
   f. Categories of lead concentration in humans.

Preparation for Next Lesson:

Read p. 140 in text and check the library for availability of the suggestions for further reading on p. 141.

ENVIRONMENTAL CHEMISTRY – 106

INTRODUCTION

Environmental Chemistry is a second semester course in a two-year program in chemical and environmental technology. It consists of 30 hours of lecture, 10 hours of laboratory work, 3 hours for field trip, 3 hours for films and 2 hours for guest lecturers. The laboratory, film and guest lecturer time will be taken from the listed 3 hour lecture time as convenient. Therefore, the lecture outline includes 45 hours of time and not 30 hours. The class meets for a three hour session once a week for 16 weeks. The final exam is given after the 26th week. It is a three credit course.

The course is presented in two parts; air pollution is considered first and then water pollution. The material is designed to give the student a realistic and objective picture of the pollution problem. This in turn helps him use technology to find solutions with less emotion than if he relied on the mass media.

GENERAL OBJECTIVES

The student will be able to:

1. Identify the chemicals which cause air and water pollution and their harmful effects.
2. Evaluate the causes of air and water pollution and develop ways to decrease or eliminate the pollutants.
3. List the ways that he as an individual can help in his daily life to prevent pollution and the depletion of our natural resources.
4. Research the literature dealing with environmental problems.
5. Develop the ability to correctly assemble and use the apparatus for environmental work.

CAREER OBJECTIVES

The student will be able to:

1. Apply knowledge of chemistry and environment in giving direct technical assistance to chemists engaged in environmental research and experimentation.
2. Develop, design or plan modifications of new products, techniques and processes under the supervision of environmental chemists in research, design and development.
3. Assume responsibility for: performance tests of environmental apparatus, determinations, tests, analyses of substances; and the preparation of appropriate technical reports covering the tests.
4. Communicate in the language of environmentalists and be able to comprehend instructions for proper performance in the laboratory and in the field.
5. Perform his duties and display a broad understanding of environmental studies to insure rapid advancement, both financially and in job responsibilities.

TOPICAL OUTLINE

This outline is divided into 15 sections, each one corresponding to a three hour session.

LECTURE		30 HRS.
Section 1	Air Pollution – General Considerations	3
Unit 1.1	A comparison of unpolluted vs. polluted air	
Unit 1.2	Types of air pollutants	
Unit 1.3	Units of measurement	
Section 2	Carbon Monoxide	3
Unit 2.1	Sources of carbon monoxide pollution	
Unit 2.2	Concentration, distribution and effects of carbon monoxide pollution	
Unit 2.3	Control of carbon monoxide pollution	
Section 3	Oxides of Nitrogen	3
Unit 3.1	Sources of NO_x pollution	
Unit 3.2	Concentration, distribution and effects of NO_x pollution	
Unit 3.3	Control of NO_x pollution	
Section 4	Hydrocarbons and Photochemical Oxidants	3
Unit 4.1	Sources of hydrocarbon pollution	
Unit 4.2	Concentration, distribution and effects of hydrocarbon pollution	
Unit 4.3	Control of hydrocarbon pollution	
Section 5	Sulfur Oxides	3
Unit 5.1	Sources of SO_x pollution	
Unit 5.2	Concentration, distribution and effects of SO_x pollution	
Unit 5.3	Control of SO_x pollution	
Section 6	Particulates	3
Unit 6.1	Sources of particulates	
Unit 6.2	Concentration, distribution and effects of particulate pollution	
Unit 6.3	Control of particulate pollution	
Section 7	Temperature Inversions and the Greenhouse Effect	3
Unit 7.1	The effect of temperature inversions	
Unit 7.2	The disruption of the carbon cycle	
Unit 7.3	Smog	
Section 8	Water Pollution – General Considerations I	3
Unit 8.1	A comparison of unpolluted vs. polluted water	
Unit 8.2	Biochemical oxygen demand (BOD)	
Unit 8.3	Disease-causing agents and plant nutrients	

		HRS.
Section 9	Water Pollution – General Considerations II	3
Unit 9.1	Inorganic chemicals and mineral substances	
Unit 9.2	Radioactive materials	
Unit 9.3	Thermal pollution	
Section 10	Mercury	3
Unit 10.1	Sources of Mercury pollution	
Unit 10.2	Mercury in the food chain	
Unit 10.3	Solutions to the mercury problem	
Section 11	Lead	3
Unit 11.1	Sources of lead pollution	
Unit 11.2	The behavior of lead in the body	
Unit 11.3	Solutions to the lead problem	
Section 12	Detergents	3
Unit 12.1	Pollution problems involving detergents	
Unit 12.2	Nonphosphate detergents	
Unit 12.3	Phosphate removal and the environment	
Section 13	Synthetic Organic Insecticides	3
Unit 13.1	Toxicity of insecticides	
Unit 13.2	The effects of DDT	
Unit 13.3	Alternatives to DDT	
Section 14	Oil	3
Unit 14.1	Sources and causes of oil pollution	
Unit 14.2	Biological and physical effects	
Unit 14.3	Countermeasures for oil pollution	
Section 15	Waste Water Treatment	3
Unit 15.1	Primary treatment process	
Unit 15.2	Secondary treatment process	
Unit 15.3	Tertiary treatment processes	

FINAL EXAMINATION

LECTURE OBJECTIVES

The student will be able to:

Section 1. Identify the major air pollutants, their sources, relative amounts in the air and the accepted ways of expressing their concentration.

Section 2. List at least five ways that carbon monoxide is released into the atmosphere, explain in writing how carbon monoxide reacts with the hemoglobin in the blood and describe two of the current methods being used to control carbon monoxide pollution.

Section 3. Identify the three major sources of nitrogen dioxide and the factors that affect its distribution. Explain, in writing, the toxic effects of nitrogen oxides and describe two of the current methods being used to control nitrogen oxide pollution.

Section 4. Explain, using necessary equations, the chemical reactions, the sources and the harmful effects of hydrocarbon pollution, and list four current methods of controlling this type of pollution.

Section 5. Identify the two major sources of sulfur dioxide pollution and the factors that affect its distribution. Explain, in writing, the harmful effects of sulfur oxides and describe four possible methods for reducing sulfur oxide pollution including their advantages and disadvantages.

Section 6. List the five major sources of particulate pollution. Explain, in writing, their harmful effects and using diagrams describe the four types of equipment currently used to capture particulates before they enter the atmosphere.

Section 7. Explain, in writing, the atmospheric conditions which cause: temperature inversions, the disruption of the carbon cycle by man and how it leads to the greenhouse effect, and the factors that contribute to the environmental condition known to the public as "smog."

Section 8. Identify the major pollutants of water, their sources and relative amounts. Define BOD and list three serious diseases caused by polluted water.

Section 9. Describe, in writing, using appropriate diagrams and equations the effects of: 1) inorganic chemicals, 2) mineral substances, 3) radioactive materials and 4) heat on the pollution of water and their harmful effects on animal and plant life.

Section 10. List three major sources of mercury pollution and tell how it gets into the water. Explain, in writing, how mercury gets into the human body and its toxological effects. Recommend three methods of preventing further mercury pollution and two methods of removing existing contamination from rivers and lakes.

Section 11. Describe, with equations, the properties of lead, its legitimate uses, the sources of pollution, its toxic effects on man and list three possible solutions for reducing the amount of lead pollution.

Section 12. Write chemical equations for various types of detergents and describe the pollution problems involved with each type. Evaluate soap and NTA as alternatives to detergents, and list three arguments, pro and con for removing phosphates from detergents.

Section 13. Describe, in writing, with the assistance of diagrams the properties, uses and toxic effects of synthetic organic insecticides. Draw a diagram of the food chain from the application of DDT until it reaches the human body and list three types of insecticides that are currently being used or considered as alternatives to DDT.

Section 14. Explain, in writing, the sources and causes of oil pollution. Categorize the short-term and long-term biological and physical effects of oil pollution. Identify the counter measures now being used and others which could be used to prevent and control oil pollution.

Section 15. Describe, in writing, with the use of illustrations the primary, secondary and tertiary treatments of wastewater with emphasis on the activated sludge process and the electrodialysis cell.

LABORATORY EXPERIMENTS CH–106

The six laboratory experiments outlined in this syllabus do not require any elaborate setups of apparatus and are designed, with the exception of number 6 which is a semester project, to be worthwhile experiences for one hour segments of the course. They are adapted from various sources which are properly identified.
These experiments will be performed as follows:

1. During the fourth meeting of the class the third hour will be used to setup the air blower and the fiberglass filter. This will be done by the entire class. Also, written instructions to the students will be distributed and discussed concerning the tests to be performed. The following week pairs of students will perform the tests for the metallic air pollutants and total particulate matter. This lab fits into the overall study of air pollution.

2. This lab will be performed by the entire class during the eighth week to correlate with the lecture. Each student will be required to bring a sample of water into class for testing. He will then be assigned one of the test kits to test each sample of water and a data table will be prepared for comparison. The water samples will be saved for the following week.

3. During the ninth week, to correlate with the lecture, the class will go out to the pond in the back of the school property to test the water for conductivity. The water samples tested the previous week will also be tested for conductivity. In this way each student will become familiar with the conductivity apparatus.

4. The mercury analyzer will be used during the tenth week to correlate with the lecture. Each student will be required to bring some sample of marine life to class with him and he will test it for mercury content.

5. The testing of gasolines for lead content will be performed during the eleventh week to correlate with the lecture. There should be enough samples to allow pairs of students to completely test one gasoline. A table of data will be prepared for comparison purposes.

6. At the beginning of the course, the instructor will determine if any students wish to go into the environmental field. If so, it will be suggested that they do this experiment as part of the course in quantitative analysis.

The course is taught as a combination of lecture and laboratory experiments. The lectures are informal in the sense that the students are encouraged to ask questions and to work out assigned problems on the blackboard. Reading assignments are made before the lectures to prepare the student for the lecture. Problems from the text are assigned which are appropriate for the material covered in the lecture.

The textbooks and periodicals listed under references are readily available from the instructor and are found either in the lab or in the library. The reference books which are available should be sufficient for most research purposes.

The overhead projector is used for instructor prepared transparencies and for the K & E transparency masters listed under learning aids. Rented films are shown when available.

The experiments are performed on an individual basis. Demonstrations to the entire class are given when appropriate, but more often the instructor will demonstrate a proper procedure to a student who may be having difficulty. Since there are more potential hazards when using organic chemicals, the instructor points out to the class before starting an experiment where these hazards may arise and how to prevent or minimize them. Close supervision of the students' work is necessary both for reasons of safety and for the development of proper techniques.

TEXTBOOKS

The textbooks for Chemistry 201 and 202 are:

1. *Organic Chemistry:* A Short Course, H. Hart and R. D. Schuetz, Fourth Edition, Houghton Mifflin Co., 1972.
2. *Experimental Organic Chemistry*, C. A. MacKenzie

EVALUATION OF STUDENTS CH–201

The students are evaluated on their test results, laboratory performance, laboratory proficiency, laboratory notebook, homework assignments, professional attitude and class participation. A composite grade of 70% would be necessary for them to receive a letter grade of "C" for the course.

1. Tests:

Seven tests, including the final examination are given during the course at the times specified. Some of the tests may be actual laboratory problems completed under test conditions. The written tests are based upon the behavioral objectives. Unannounced quizzes may be given at any time. A quiz could be anything from a single problem or essay taking 10 minutes up to what might be considered an extra test. After the fourth test, each student is individually counseled concerning his progress to that point. His performance is discussed and if improvement is required, he is informed of his deficient areas and what is expected of him in order to receive at least a "C" grade for the course. For students who are not making much progress, counseling is necessary before this point. Tests and quizzes are devised in such a way as to reflect the attainment of the objectives of the course. A student who averages 90 or better will get an "A" for the course. A grade of 75 to 90 would be in the "C" to "B" range. A student scoring between 60–75 needs extra help before continuing, and one who scores less than 60 is in danger of failing the course.

Written tests will be given after the following points in the outline:

Test # 1	After Unit 1.4	1 hour
Test # 2	After Unit 3.6	1 hour
Test # 3	After Unit 4.3	1 hour
Test # 4	After Unit 5.4	1 hour
Test # 5	After Unit 7.3	1 hour
Test # 6	After Unit 8.5	1 hour
FINAL EXAMINATION		3 hours

2. Laboratory Performance:

A rating sheet for lab performance is included as an appendix. It is filled out at least twice during the quarter for each student and more frequently if there is any observable improvement or deterioration in a student's performance. If a student gets 125 or better out of a maximum 155 points, he is doing an excellent job in the lab. A score of 100 to 125 indicates that there are some areas that need improvement. When the score is below 100, the instructor should give the student individual counseling to discuss his chances of passing the course.

3. Laboratory Proficiency:

Manual ability is evaluated by observation of such operations as:

a. Making measurements – For volumes this includes filling and partially emptying volumetrically calibrated equipment like cylinders and burets, reading the bottom of the meniscus accurately. For weights choosing the proper balance for the job, adjusting it to its zero position, and using the balance gently to avoid sudden jars to its delicate mechanism.

b. Filtering – Most filtering in the organic lab is performed with a Buchner funnel and vacuum. Proper setting of the filter paper in the funnel, proper control of the vacuum, pouring to prevent overflow and careful removal of the paper and the filtered solid are points to be observed.

c. Washing glassware thoroughly – to avoid possible contamination.

d. Transferring – Transferring chemicals from one container to another without spilling or causing contamination. Special emphasis is placed on observing the dispensing of small amounts of liquids with medicine droppers.

e. Setting up apparatus according to instructions – with special emphasis on the prevention of a closed system. Glass bends, when used, should be properly made to prevent safety hazards.

f. The proper use of a separatory funnel – When this piece of equipment is used with a volatile liquid it must be vented with every rotation to prevent its bursting from built up pressure.

g. Setting up a distillation apparatus – Here the student must go through a check list for proper operation.

h. Handling hazardous chemicals – Handling chemicals such as sodium metal, calcium carbide and others in a safe manner.

i. Heating flasks – Heating with electric heating mantles and using flames only when instructed.

j. In general – Observations are made as to how well the student follows instructions. The student will also be questioned frequently to evaluate his ability to relate theory to practice in the laboratory.

4. **Laboratory Notebook:**

The notebook is a record of the student's work in the lab and should be kept up to date. A delay between performance and recording usually results in a low grade and making notes and calculations any place but the notebook is discouraged. The notebook should contain for each experiment:

a. Title of the experiment
b. Dates of performance and completion
c. A statement as to the purpose of the experiment

d. Equations used
e. A qualitative description of the procedure followed with observations.
f. Amounts of materials used (in a tabular form)
g. Data collected and yield calculations (in a tabular form).
h. Observed or determined properties of the product (color, physical state, melting point, boiling point, etc.)
i. Alternative methods of preparation.
j. Answers to questions asked in the manual or supplied by the instructor.
k. Personal comments or suggestions for improvement.

No specific format is required, but the student will be graded on neatness, completeness and accuracy of results. If the student does not get the desired result, he can improve his grade by including a section in his report giving possible reasons for his incorrect result.

The notebooks are collected and graded about every 10 days.

5. **Homework Assignments:**

Homework problems are assigned but not collected. Instead, students are selected at random to show their solutions to the class and are given grades for their presentation. Any homework problem which was found difficult by the entire class is explained by the instructor.

6. **Professional Attitude:**

This is a subjective evaluation on the part of the instructor of those aspects of a student's character which will have a bearing on his ability to perform successfully as a chemical technician.

7. **Class Participation:**

The student is evaluated for his participation in and contributions to class discussions, answering the instructor's questions, asking pertinent and relevant questions and also by a random evaluation of lecture notes.

SAMPLE LESSON PLAN CH–201 SECTION 2, UNIT 2.1: STRUCTURE AND NOMENCLATURE OF SATURATED HYDROCARBONS

Objective:

To be able to name an alkane from its structural formula or to give the structural formula when given its name.

Preparation:

Textbook (Chapter 2, pages 20-27)

Introduction:

There are well over a million organic compounds. It is obvious that they all need a name to differentiate between them. We will now start our study of a universally accepted system of naming organic compounds.

Connection with Previous Lesson:

The unique character of the carbon atom and its ability to form almost indefinite chains. Structural formulas and isomers have been introduced but no attempt has been made to this point to explain how their names were derived.

Presentation:

Lecture, discussion, blackboard illustrations with oral questions, stick models and work sheet.

Teaching Points:

1. Necessity of a system of nomenclature.
2. International Union of Pure and Applied Chemistry. IUPAC
3. Alkane
4. Longest continuous chain – basis for name root.
5. Number carbon atoms from end nearest to branching.
6. Radicals; alkyl groups.
7. Numbers are separated by a comma and a hyphen is placed between the numbers and the name.
8. Prefixes di, tri, tetra, etc.
9. Primary, secondary and tertiary carbon atoms.

Classwork:

Write some formulas on board and have students name them.

Write names on board and have student give structural formulas. Pass out prepared work sheet for students to practice with in class.

Homework:

1 – Read pages 27–35

2 – Problems 1, 2, 3, 4, 5, 6, 7 on page 44–45.

ORGANIC CHEMISTRY I CH–201

Third Semester	(16 weeks)
Lecture:	4 hours per week
Laboratory:	6 hours per week
Credits	6

INTRODUCTION

Organic Chemistry I is the third semester course of the core program. It consists of 64 hours of lecture and demonstration (4 hours per week) and 96 hours of laboratory work (6 hours per week) and is a 6 credit course. The final exam (3 hours) is given after the 16th week.

The study of organic chemistry requires an understanding of the fundamentals of chemistry. The first three career courses are therefore prerequisites. This course is designed to provide the chemical technician with some knowledge of organic chemistry and some of the skills necessary for handling and manipulating the organic laboratory apparatus which will be used for the first time in this course.

COURSE OBJECTIVES

The objectives of this course are to:

1. Develop the ability to correctly assemble the pieces of apparatus used in an organic chemistry laboratory.
2. Keep all apparatus clean and in its proper place so that it is always ready.
3. Take all necessary safety precautions in the laboratory by recognizing and anticipating potential hazards.
4. Correctly select the proper equipment and chemicals for the particular experiment.
5. Develop the ability to anticipate the effect that a change in conditions could have on the outcome of an experiment.
6. Explain the laws and theories which govern the way a reaction proceeds.
7. Develop the necessary skills in the recording of data for neatness, accuracy and completeness.
8. Keep an up-to-date notebook which includes all the relevant data for each experiment attempted.
9. Research the literature to prepare for an experiment or when new problems are encountered.
10. Maintain the laboratory in a clean, safe and orderly manner to insure efficiency.

CAREER OBJECTIVES

The student will be able to:

1. Apply knowledge of chemistry in giving direct technical assistance to chemists engaged in organic research and experimentation.
2. Develop, design or plan modification of new products, techniques and processes under the supervision of a chemist in applied chemical or related research.
3. Assume responsibility for: performance tests of chemical apparatus, determinations, tests, analyses of substances; and the preparation of appropriate technical reports covering the tests.
4. Communicate in the language of organic chemists and be able to comprehend instructions for performance in the organic laboratory.
5. Function as an essential member of the organic chemistry research and production team.
6. Perform his duties and display a broad understanding of organic chemistry to insure rapid advancement, both financially and in job responsibilities.

TOPICAL OUTLINE

LECTURE		64 HRS.
Section 1	General Principles	8
Unit 1.1	The Carbon Atom and Bonding	2
Unit 1.2	Structural Formulas and Isomerism	2
Unit 1.3	Geometry of Carbon Bonds	2
Unit 1.4	Covalent Bond Cleavage	2
Section 2	Saturated Hydrocarbons	8
Unit 2.1	Structure and nomenclature	2
Unit 2.2	Alkyl radicals	1
Unit 2.3	Physical Properties and Chemical Reactions	2
Unit 2.4	Preparation	1
Unit 2.5	Cycloalkanes	1
Section 3	Unsaturated Hydrocarbons	8
Unit 3.1	Structure and nomenclature	2
Unit 3.2	Physical Properties and Chemical Reactions	2
Unit 3.3	Preparation	1
Unit 3.4	Petroleum Refining	1
Unit 3.5	Alkynes	1
Unit 3.6	Dienes and Polynes	1
Section 4	Aromatic Hydrocarbons	6
Unit 4.1	Benzene Structure	1
Unit 4.2	Nomenclature	2
Unit 4.3	Reactions of aromatic compounds	3
Section 5	Alcohols and Phenols	5
Unit 5.1	Nomenclature and classification	1
Unit 5.2	Physical properties and Preparation	2
Unit 5.3	Reactions	1
Unit 5.4	Thiols	1
Section 6	Ethers	5
Unit 6.1	Nomenclature	2
Unit 6.2	Physical properties and preparation	2
Unit 6.3	Epoxides and sulfur analogs	1
Section 7	Organic Halogen Compounds	6
Unit 7.1	Preparation and uses in synthesis	4
Unit 7.2	Organometallic compounds	2

		HRS.
Section 8	**Aldehydes and ketones**	**7**
Unit 8.1	Nomenclature	1
Unit 8.2	Occurrence, Properties and Uses	2
Unit 8.3	Preparation and Reactions	2
Unit 8.4	The Carbonyl Group	1
Unit 8.5	Polymers from aldehydes	1
Section 9	**Carboxylic acids and their derivatives**	**11**
Unit 9.1	Nomenclature	1
Unit 9.2	Physical properties	1
Unit 9.3	Preparation and Reactions	2
Unit 9.4	Salts and Esters	2
Unit 9.5	Acid Halides and Anhydrides	2
Unit 9.6	Amides	2
Unit 9.7	Formic acid and Oxalic aicd	1

FINAL EXAMINATION AFTER THE 16TH WEEK

OBJECTIVES OF CH–201 LECTURES

The student will be able to:

Section 1	A. Write his own definition of organic chemistry with special emphasis on the unique character of the carbon atom and covalent bonding. B. Draw structural formulas and isomers.
Unit 1.1	Differentiate between ionic and covalent bonding.
Unit 1.2	Draw structural formulas showing the arrangement of the atoms within an organic molecule.
Unit 1.3	Describe, by illustrations, the geometry of carbon bonds.
Unit 1.4	Define, in writing, the terms carbonium ion, carbanion, free radical, electrophile, nucleophile and functional group.
Section 2	A. Identify and name saturated hydrocarbons by the IUPAC system. B. List the physical properties, reactions and methods of preparation of alkanes.
Unit 2.1	Name an alkane from its structure or draw it when given its name in writing.
Unit 2.2	Write the five rules of the IUPAC system of nomenclature.
Unit 2.3	Show, using equations, the important chemical reactions of alkanes.
Unit 2.4	Show, using equations, the important methods of preparing alkanes.
Unit 2.5	Draw stable confirmations of cycloalkanes.
Section 3	A. Identify and name unsaturated hydrocarbons by the IUPAC system. B. List the physical properties, reactions and methods of preparation of alkenes, dienes and alkynes.
Unit 3.1	Name an alkene from its structure or draw it when given its name in writing.
Unit 3.2	Show, by equations, the important chemical reactions of alkenes.
Unit 3.3	Show, by equations, the important methods of preparing alkenes.
Unit 3.4	Write the important reactions involved in the refining of petroleum.
Unit 3.5	(Units 3.1, 3.2 and 3.3 for alkynes)
Unit 3.6	(Units 3.1, 3.2 and 3.3 for dienes)

Section 4 Differentiate between aliphatic and aromatic compounds by writing an essay on the distillation of coal tar.

Unit 4.1 Write a short essay on the Kekule formula of benzene including the phase "resonance hybrid."

Unit 4.2 Identify and name benzene derivatives or draw their structures from written names.

Unit 4.3 List the methods of preparation of benzene and show by equations the important reactions of benzene and its derivatives.

(In Sections 5 through 9, the unit objectives when taken together constitute the objective of the Section)

Section 5

Unit 5.1 Identify, name and classify alcohols and phenols or draw their structures from written names.

Unit 5.2 List the physical properties of alcohols and phenols and show, with equations, the important methods of preparation.

Unit 5.3 Show, by equations, the important reactions of alcohols and phenols.

Unit 5.4 Show, by equations, that thiols and alcohols have many reactions in common.

Section 6

Unit 6.1 Identify and name ethers or draw their structures from written names.

Unit 6.2 List the physical properties and uses of ethers and show, by equations, the important methods of preparation and the important reactions.

Unit 6.3 Show, by equations, the important reactions of epoxides and sulfur analogs of ethers.

Section 7

Unit 7.1 Show with equations the important methods of preparing organic halides and make a list showing their versatility as intermediate compounds.

Unit 7.2 List some important organometallic compounds such as tetraethyl lead and mercurochrome and show, by equations, the preparation of a typical Grignard reagent.

Unit 7.3 List some important polyhalogen compounds such as carbon tetrachloride, chloroform, the freons and DDT including equations for preparation.

Section 8

Unit 8.1 Identify and name aldehydes and ketones or draw their structures from written names.

Unit 8.2 List some properties and uses for aldehydes and ketones.

Unit 8.3 Show, by equations, the important methods of preparation and the important reactions of aldehydes and ketones.

Unit 8.4 Define in essay form keto-enol tautomerism and the bonding in the carbonyl group.

Unit 8.5 Show, by equations, how the polymers Delrin and Bakelite are prepared from aldehydes.

Section 9

Unit 9.1 Identify and name carboxylic acids or draw their structures from written names.

Unit 9.2 List the important physical properties of carboxylic acids.

Unit 9.3 Show, by equations, the important methods of preparation and the important reactions of carboxylic acids.

Unit 9.4 A. Explain, with equations, the mechanism of esterification.
B. Show, by equations, the important reactions of esters.
C. Show, by equations, the production of a polyester such as Dacron.

Unit 9.5 Show, by equations, the important methods of preparation and the important reactions of acid halids and anhydrides.

Unit 9.6 Show, by equations, the important methods of preparation and the important reactions of amides with special emphasis on urea.

Unit 9.7 Show, by equations, the unique character of formic and oxalic acids.

OVERALL OBJECTIVE

Starting with section 3, the student should be able to show, by equations, the conversion of one organic compound to another. Obviously, this becomes more and more complex, involving an increasing number of steps, and it is important that the individual unit objectives be met for the student to accomplish this successfully at the end of the course.

ORGANIC CHEMISTRY LABORATORY EXPERIMENTS

Lab Manual: *Experimental Organic Chemistry* by C.A. MacKenzie, Third Edition, Prentice-Hall, Inc., 1967.

Preliminaries to Lab Work	Hours
1. Check in of equipment and keys	3
2. Safety procedures	1
3. Discussion of proper use of organic equipment and instructions for report writing.	2

Experiment Number	Manual Number	Hours	Title of Experiment
1	1	3	Melting Point
2	2	4	Recrystallization
3	3	4	Distillation
4	4	4	Steam Distillation
5	5	4	Fractional Distillation
6	6	4	Extraction
7	8	4	Alkanes, Alkenes and Acetylene
8	9	1	Principles of Organic Synthesis (Reading Assignment)
9	10	4	Preparation of Cyclohexene
10	11	4	Trans-Addition of Bromide to Maleic and Fumaric Acids
11	12	5	Aromatic Compounds
12	13	4	Relative Rates of Electrophilic Aromatic Substitution Reactions
13	14	4	Preparation of Nitrobenzene
14	16	4	Alcohols and Phenols
15	17	6	Preparation of o-p Nitrophenols
16	18	4	Preparation of n-Butyl Bromide
17	19	4	Halogen Compounds
18	20	4	Reaction Rate for the Hydrolysis of t-Butyl Chloride
19	21	5	Preparation and Properties of Ethers
20	(Inst. Handout)	4	Aldehydes and ketones
21	28	4	Carboxylic Acids, Amides and Nitrites. Preparation of Adipic Acid
22	35	6	Properties of Esters

LABORATORY OBJECTIVES

The student will be able to:

Experiment 1:
A. Determine the melting point of a compound by capillary tube and Fisher-Johns apparatus.
B. Recognize that an impure compound will not melt sharply.
C. Identify an unknown sample by its melting point.

Experiment 2:
A. Choose a suitable solvent for recrystallization
B. Assemble an efficient filtration apparatus.
C. Correctly perform a recrystallization procedure, resulting in a pure product at a high yield.

Experiment 3:
A. Sketch a vapor pressure-temperature graph given at least five points, and then interpolate other values.
B. Safely test for the flammability of a compound.
C. Assemble and safely operate a distillation apparatus.
D. Determine the boiling point of a pure compound by the capillary method.
E. Compare boiling points and molecular weights.

Experiment 4:
A. Determine from solubility data, vapor pressures and molecular weight if steam distillation is an appropriate method of purification.
B. Assemble and safely operate a steam distillation apparatus.
C. Obtain a relatively pure product at good yield from a steam distillation.

Experiment 5:
A. Find the vapor pressure of a mixture of compounds using Raoult's law with data from the handbook.
B. Plot a vapor-liquid composition curve for two liquids and determine if fractional distillation is a suitable method of separating them.
C. Assemble and safely operate a fractional distillation apparatus.
D. Obtain at least 90% separation of a mixture of toluene and carbon tetrachloride.

Experiment 6:
A. Choose a suitable solvent for extracting a compound from water solution.
B. Work in a safe manner with ether.
C. Extract water-soluble dyes with ether.
D. Extract water-soluble dyes by salting-out.
E. Determine a distribution coefficient by ether extraction and titration.
F. Estimate a distribution coefficient by colorimetry.
G. Extract one compound from another by counter current distribution.

Experiment 7: A. Determine the densities of an alkane and an alkene to three digit accuracy.

B. Determine their index of refraction with both the Fisher and Abbe refractometers.

C. Test them for unsaturation with $KMnO_4$ solution and with bromine in $CC1_4$

D. Test them for possible reaction with H_2SO_4.

E. Assemble an acetylene generator and safely operate it.

F. Prepare, test and safely dispose of silver acetylide.

G. Assemble an ethylene generator and safely operate it.

Experiment 8: This is a reading assignment which is a compilation of many of the factors which are considered in the development of a successful synthesis of an organic compound. They are discussed in the laboratory at this time and are referred to throughout the course, both by the instructor and the students.

The objective is to prepare the student for subsequent experiments of the synthesis type and to encourage him to re-read this material before each preparation assignment which will increase his ability to start an experiment with more self-reliance and will enable him to perform his work with more understanding.

Experiment 9: A. Prepare a relatively pure sample of cyclohexene from cyclohexanol at a suitable yield.

B. Choose a suitable inorganic drying agent to purify organic liquids by removing water.

Experiment 10: A. Prepare the meso form of dibromo-succinic acid from sodium maleate and sodium fumarate.

B. Prepare a flow diagram for the preparation from sodium fumarate.

Experiment 11: A. Compare an aromatic hydrocarbon with an alkane and a cycloalkane by testing such properties as solubility, flammability, and reactions with $KMnO_4$ solution and sulfuric acid.

B. Prepare a nitro derivate of benzene, toluene or xylene, and test its purity by a melting point.

Experiment 12: A. Measure the time required for the bromination of various organic compounds in the absence of catalysts as an example of the rates of aromatic substitution reactions.

B. Determine the effect of temperature changes on reaction rates by plotting the results on a graph with 1/t (sec) as the ordinate and absolute temperature as the abscissa.

Experiment 13: A. Prepare nitrobenzene in a relatively pure form and in good yield by the process of nitration.

B. Test for the presence of nitro impurities with sodium hydroxide in acetone.

C. Test for the presence of a nitro group by converting it to an amino group with ferrous ammonium sulfate.

D. Choose the conditions necessary for the nitration of various aromatic compounds.

Experiment 14: A. Identify alcohols as primary, secondary or tertiary by b.p., solubility and flammability tests, testing with ceric nitrate, Lucas reagent and by forming derivates.

B. Identify phenol compounds by the ceric nitrate test, the Lucas test, by forming derivates and other tests.

Experiment 15: A. Prepare o- and p-nitrophenol by the nitration of phenol.

B. Separate the two compounds by recrystallization with benzene.

Experiment 16: A. Prepare n-butyl bromide from n-butyl alcohol in relatively pure form and in good yield.

B. Assemble a reaction apparatus in which the receiver is at a higher elevation than the reaction flask.

Experiment 17: A. Classify halogen compounds as aliphatic or aromatic.

B. Identify a halogen as chloride, bromide, or iodine.

C. Perform the following new tests to meet objectives A and B: Beilstein test, Alcoholic silver nitrate and sodium iodide in methyl ethyl ketone.

D. Prepare a thiourea derivative of a halogen compound to identify it.

Experiment 18: A. Measure the reaction rate for the hydrolysis of t-butylchloride under several conditions of concentration and temperature.

B. Calculate the rate constant, k, for the reaction from the integrated first order rate law.

C. Calculate the activation energy for the reaction from the slope at the line when – log k is plotted against the reciprocal of the absolute temperature cubed.

Experiment 19: A. Prepare n-butyl ether from n-butyl alcohol in relatively pure form and in good yield.

B. Prepare n-butyl ethyl ether by the Williamson synthesis in relatively pure form and in good yield.

C. Prepare nitro derivatives of phenetole and anisole in relatively pure form and in good yield.

D. Test for the presence of peroxides in ethers and remove the peroxides by shaking the ether with weakly acidified ferrous ammonium sulfate.

E. Assemble an apparatus that will allow for the removal of water during the reaction.

Experiment 20: A. Test for the presence of aldehydes and ketones by the Schiff test and with oxidizing agents.

B. Prepare a small amount of acetaldehyde by oxidizing ethyl alcohol and a small amount of formaldehyde by oxidizing methyl alcohol.

C. Distinguish an aldehyde from a ketone as a result of the tests.

Experiment 21: A. Prepare adipic acid from cyclohexanol in relatively pure form and in good yield.

B. Prepare an anilide or a p-toluidide from a carboxylic acid in relatively pure form and in good yield.

C. Prepare an amide derivative of xanthydrol in relatively pure form and in good yield.

Experiment 22: A. Identify an ester by hydrolysis, ammonolysis, ferric hydroxamate test and by making a derivative with benzylamine.

Certain objectives could be listed under all of these experiments and others could be listed under most of them. These overall objectives include:

1. Keep thorough and accurate results in the notebook.
2. Turn in neat, complete and accurate lab reports.
3. Follow directions very carefully.
4. Show increasing proficiency in the use of equipment.
5. Keep all glassware and other equipment scrupulously clean.
6. Dispense chemicals from their containers in a safe and careful manner.
7. Observe all safety precautions including use of hoods, keeping flame away from flammables and disposing of waste materials in a proper way.
8. Apply the principles and skills learned in one experiment to succeeding experiments where the reactions are similar or the product to be made is similar.

The course is taught as a combination of lecture and laboratory experiments. The lectures cover theoretical aspects of chemical instrumentation. They are intended to answer the "how" type of question; what is going on inside the instrument during an analysis. They are of an informal nature, where the student is encouraged to participate by asking questions. The student is encouraged to bring pertinent information into class for discussion purposes and to explain his solutions to assigned problems or findings from his laboratory work. Reading material is assigned to prepare the student for the lectures and problems. Other assignments such as library research are also made to reinforce or add to the original lecture.

The laboratory experiments are not concurrent with the lectures. Concurrence would require about four of the same kind of each instrument to allow all the students to be working on the same experiment at one time. Expense prohibits this . The class is divided into four groups and each group starts experimental work on one of the four major instrumental groups. These groups are ultra-violet and visible spectrophotometry, infra-red spectrophotometry, chromatography and titration techniques. The groups rotate within these four areas until the following laboratory experiments are appropriate: 1 through 6, 9, 12 and 13. The other experiments are performed either after these have been completed or when something prevents the proper rotation of the groups.

Demonstrations to the group by the instructor are given when appropriate. The experiments are performed on a small group basis and laboratory reports are written either as group or individual efforts. Close supervision of the student's work is necessary for reasons of safety, for the development of proper techniques, and to maintain the instruments in proper working order.

The text books, references and periodicals listed in this syllabus are available either in the lab, from the instructor, or from the school library. It may sometimes be necessary to prepare "Information Sheets" if it is felt that the text does not cover the subject too well.

Guest lecturers are invited to lend expertise on particular instruments. There are many industrial contacts including our alumni who are very capable. Some of these resource people are listed in another section of this syllabus. Charts, graphs, pictures and cartoons can and should be collected and used as needed during the presentation of the lectures. Films and slides are shown where they are deemed appropriate and are available. The overhead projector is frequently used since there are many diagrams and illustrations which are part of this course. Field trips can be useful and some suggestions appear in another section of this syllabus.

TEXTBOOKS

The textbooks to be used for Chemistry 215 are:

1. *Instrumental and Separation Analysis*, C. T. Kenner, Charles E. Merril Publishing Co., Columbus, Ohio 1973

2. *Optical Techniques of Chemical Analysis*, T. W. Boyd, Vocational-Technical Curriculum Laboratory, Rutgers – The State University, New Brunswick, N. J. 1973

EVALUATION OF STUDENTS

The students are evaluated on their test and quiz results, laboratory proficiency, laboratory reports, homework assignments, professional attitude and class participation. A composite grade of 70% would be necessary for a student to receive a letter grade of "C" for the course.

These factors are apportioned as follows:

1.	Tests and quizzes	25%
2.	Laboratory reports	25%
3.	Final Exam	25%
4.	Homework	15%
5.	Professional attitude and class participation	10%
		100%

1. **Tests and Quizzes:**

Four tests, including the final examination, are given during the course at the times specified. At least one of the four tests shall consist of completion of a laboratory problem so that the instructor may observe skills listed in the objectives. Unannounced quizzes may be given at any time. A quiz may be anything from a single problem or short essay taking 10 minutes up to what might be considered an extra test. They are weighted less than a test since the student has not prepared himself in the same way he does for a test. After the second test, each student is individually counseled concerning his progress to that point. His performance is discussed and if improvement is required he is informed of his deficient areas and what is expected of him in order to receive at least a "C" grade for the course. For students who are not making much progress, counseling is necessary before this point. Tests and quizzes are devised in such a way as to reflect the attainment of the objectives of the course. A student who averages 90 or better will get an "A" for the course. A grade of 75 to 90 would be in the "C" to "B" range. A student scoring between 60 to 75 would need extra help before continuing and one who scores less than 60 is in serious danger of failing the course.

Written tests will be given after the following points in the course outline:

Test # 1	Section 3	1 hour
Test # 2	Section 7	1 hour
Test # 3	Section 10	1 hour
FINAL EXAMINATION		1½ hours

2. **Laboratory Reports:**

Laboratory reports are required from each group for each experiment. The student should keep an informal notebook for recording the data and observations necessary for making a suitable report. The report should include the following:

a. an appropriate title
b. dates of performance and completion
c. an introductory statement about the instrument used with enough of the theory to explain how the instrument was used to obtain the experimental results
d. a brief description of the procedure followed
e. a statement of the purpose of the experiment
f. materials and chemicals used
g. tables of the data collected
h. equations when they are appropriate
i. observations and conclusions based upon the data and experimental results
j. alternative methods, if any, of achieving the same or better results
k. answers to questions asked in the written instructions or orally by the instructor
l. personal comments or suggestions for improvement.

No specific format is required, but the student will be graded on neatness, completeness and accuracy of results. If the student does not obtain what he believes to be a logical result, based upon his prior knowledge, he can improve his grade by including a section in his report giving possible reasons for any discrepancies.

The students can choose to write up a group report, for which each individual in the group will receive the same grade, or each student can write up his own report.

These reports should be turned in to the instructor one week after completion of the experimental work. Although both quantity and quality are considered, a minimum of six reports is required. These six are as follows: two of the first three about chromatography, number 4 about gas chromatography, number 5 or 6 about the ultraviolet spectrophotometer, number 9 about the infra-red spectrophotometer and number 12 or 13 about the pH meter.

3. **Final Exam:**

The final exam is comprehensive in that it covers both the theoretical aspects of the course and the experimental work. It is designed to determine how well the educational process has functioned based on the objectives of the course.

4. **Homework:**

As stated in the methodology section, reading assignments and library research assignments are made to reinforce or add to the lectures. This homework will be collected, graded and promptly returned to the student since the information derived from this research will be invaluable for incorporation in the laboratory reports.

5. **Professional Attitude and Class Participation:**

Professional attitude evaluation on the part of the instructor is subjective. The instructor attempts to evaluate, on the basis of his experience, those aspects of a student's character which will have a bearing on his ability to perform successfully as a chemical technician.

Evaluating class participation is much less subjective. It is based on the student's contributions to class discussions, answering the instructor's questions, asking pertinent and relevant questions and also by a random evaluation of lecture notes.

SAMPLE LESSON PLAN CH–215

SECTION 1, UNIT 1.3: THE COMPONENTS OF SPECTROPHOTOMETERS

Objective:

The student will be able to list the major components of a spectrophotometer and explain their functions.

Preparation:

Textbook reading assignment (Chapter 3, pages 32–70).

Introduction:

Instruments have been designed which substitute a photosensitive device for the human eye as the method of measurement. The device can "see" much more than the human eye and make much more accurate measurements.

Connection with Previous Lesson:

In the two previous lessons the electromagnetic spectrum was explained. Also, the use of the human eye to determine an estimated wavelength and the laws of absorbence were discussed. At this point, the instrumental devices which substitute for the human eye can be introduced.

Presentation:

Lecture, discussion, overhead projectuals of schematic diagrams of typical instruments and the Sargent-Welch ChemAnal® arranged as an absorption spectrophotometer.

Teaching Points:

1. Classifications of Spectrophotometers
2. Light sources
3. The Optical System
4. The Wavelength Selectors
5. Light Sensitive Devices
6. Commercial Instruments

Classwork:

The student should decide which of the schematic diagrams presented meets his personal preference in terms of understanding the function of the components. He should make this decision before leaving class.

Homework:

1. Study the chosen schematic diagram
2. Read pages 74-104 in textbook.

INSTRUMENTAL ANALYSIS CH–215

Lecture:	2 hours per week
Laboratory:	3 hours per week
Credits:	3

INTRODUCTION

Instrumental Analysis is a third semester course in a two-year program in Chemical and Environmental Technology. The student who successfully completes the program will be awarded an Associate in Applied Science degree.

It consists of 32 hours of lecture and demonstration and 48 hours of laboratory work during the semester. The final exam is given after the 16th week. It is a 3 credit course.

The lectures are designed to impart the theories and laws that govern the way chemical instruments operate. The laboratory work, in 16 3-hour blocks, includes student experimentation on visible, ultra violet and infrared spectrophotometry; paper, thin-layer and gas chromatography; automatic titration, polarimetry, refraction, vicometry, radioactivity and pH measurements. All first year chemistry courses are prerequisites for Instrumental Analysis, and Organic Chemistry should be taken concurrently.

GENERAL COURSE OBJECTIVES

The student will:

1. develop the ability to correctly prepare an instrument and make necessary adjustments for an assigned laboratory task.
2. be able to read measuring devices with required precision.
3. be able to interpret the data obtained from the instrument.
4. keep all instruments clean and in usable shape and return all accessories to their proper place.
5. take all necessary safety precautions in the laboratory by recognizing and anticipating potential hazards.
6. prepare the standards required for the calibration of certain laboratory instruments.
7. make *minor* instrument repairs and maintenance.
8. develop the ability to anticipate the effect that a change in conditions could have on the outcome of an experiment.
9. explain the laws and theories which govern the way an instrument operates.
10. develop the necessary skills in the recording of data for neatness, accuracy and completeness.

11. Keep an up-to-date notebook which includes all the relevant data for each experiment attempted.
12. research the literature to prepare for an experiment or when new problems are encountered.
13. maintain the laboratory in a clean, safe and orderly manner to insure efficiency.

CAREER OBJECTIVES

The student will be able to:

1. apply knowledge of chemistry and instrumentation in giving direct technical assistance to chemists and chemical engineers engaged in quality control or research and development.
2. assist chemists and chemical engineers in developing, designing or planning modifications of new products, techniques and processes by using the information obtained from instrumentation.
3. assume responsibility for performance tests of chemical apparatus; determinations, tests, analyses of substances; and the preparation of appropriate technical reports covering the tests.
4. communicate in written work and orally in the language needed for an understanding of chemical instrumentation and be able to comprehend instructions for proper performance in the laboratory and in the field.
5. perform his duties and display a broad understanding of chemistry and its instrumentation to insure rapid advancement, both financially and in job responsibilities.

TOPICAL OUTLINE

LECTURE **32 HOURS**

Text: Instrumental and Separation Analysis, by C. T. Kenner,
Charles E. Merril Publishing Co., Columbus, Ohio, 1973.

Section 1	Visible and Ultra Violet Spectrophotometry	4 hrs.
Unit 1.1	The nature of radiant energy and its nomenclature	
Unit 1.2	The laws of absorbance and visual colorimetric methods	
Unit 1.3	The components of the instruments	
Unit 1.4	The methods of making various determinations	
Section 2	Fluorescence: Origin and Instrumentation	2 hrs.
Section 3	Infrared Spectrophotometry	4 hrs.
Unit 3.1	Absorption of infrared radiation	
Unit 3.2	The components of the instruments	
Unit 3.3	The uses of the instrument in analysis	
Unit 3.4	The interpretation of the data	
Section 4	Polarimetry	1 hr.
Section 5	Chromatography	4 hr.
Unit 5.1	The applications of column chromatography	
Unit 5.2	Paper and thin-layer chromatography	
Unit 5.3	The uses of gas chromatography in analysis	
Unit 5.4	The interpretation of the data	
Section 6	Refractometry	2 hrs.
Section 7	Potentiometric Measurements	2 hrs.
Unit 7.1	The Nernst Equation and its applications	
Unit 7.2	Potentiometric titrations	
Section 8	The pH Meter	2 hrs.
Unit 8.1	The electrodes used for pH	
Unit 8.2	The measurement of pH	
Section 9	Flame Photometry and Atomic Absorption	2 hrs.
Unit 9.1	Instrumentation and evaluation methods of flame photometry	
Unit 9.2	Instrumentation and evaluation methods of atomic absorption	

Section 10	**Emission Spectroscopy**	**2 hrs.**
Unit 10.1	**Electrodes and sample preparation**	
Unit 10.2	**Instrumentation and applications**	
Section 11	**Nuclear Magnetic Resonance**	**2 hrs.**
Unit 11.1	**The properties of the nucleus to be measured**	
Unit 11.2	**Instrumentation and applications**	
Section 12	**Mass Spectrometry**	**2 hrs.**
Unit 12.1	**Theory and instrumentation**	
Unit 12.2	**Analytical methods and evaluation of the data**	
Section 13	**Radioactive Methods**	**2 hrs.**
Unit 13.1	**Detection of radioactivity**	
Unit 13.2	**Applications in analysis**	
Section 14	**Viscometry**	**1 hr.**

FINAL EXAMINATION

LECTURE OBJECTIVES

The student will be able to:

Section 1	Explain, in writing, the nature of radiant energy, the electromagnetic spectrum and the functions of an ultra-violet spectrophotometer.
Unit 1.1	Define the words, terms and symbols used in spectroscopy.
Unit 1.2	Explain, with equations, the laws of absorbance with emphasis on Beer's and Lambert's laws.
Unit 1.3	List the major components of a spectrophotometer and explain their function.
Unit 1.4	Determine concentration from absorbance and make calibration curves; determine pH values and the formulas of complexes.
Section 2	Explain, with diagrams, the origin of fluorescence and the instrumentation used to measure it.
Section 3	Explain, in writing, the nature of infrared radiation; the instruments used to measure it and to interpret the data resulting from analyses.
Unit 3.1	Draw and explain the diagrams of vibration modes and define the words used to denote the four types of bending.
Unit 3.2	List the major components of an infra-red spectrophotometer and explain their function.
Unit 3.3	List the types of analyses which can be performed and some of those which can not be performed on this instrument.
Unit 3.4	Interpret the spectra to identify functional groups and determine the structure of the sample.
Section 4	Explain the operation of a polarimeter and calculate from given data the concentration of an unknown solution.
Section 5	Explain, with illustrations, the unifying concept of all forms of chromatography.
Unit 5.1	Explain the separation mechanism of column chromatography with emphasis on the concept of "theoretical plates."
Unit 5.2	Calculate Rf values from the results of thin layer and paper chromatography.
Unit 5.3	Draw a diagram of the typical components of a gas chromatograph and explain how each part functions.
Unit 5.4	Calculate, from chromatograms, the concentrations of components in a mixture, the number of theoretical plates and other qualitative and quantitative determinations.

Section 6	Explain the operation of a refractometer and how it is used to follow the progress of a distillation process.
Section 7	Differentiate between the two major types of potentiometric analyses: the direct measurement of an electrode potential from which the concentration of an active ion may be derived, and the changes in the EMF of an electrolytic cell brought about by the addition of a titrant.
Unit 7.1	Perform calculations using the Nernst equation for various electrode combinations.
Unit 7.2	Draw and interpret graphs of potentiometric nitrations.
Section 8	Explain the theory of pH measurements and the operation of the instrument.
Unit 8.1	List the electrodes that can be used with a pH meter and how they are used.
Unit 8.2	Calculate pH from cell potentials.
Section 9	Explain why flame photometry and atomic absorption can be studied as one unit.
Unit 9.1	List the components and the operating conditions of a flame photometer and explain the evaluation methods.
Unit 9.2	List the components and the applications of an atomic absorption spectrophotometer and explain the evaluation methods.
Section 10	Explain the applications of spectroscopy with high energy excitation of the sample.
Unit 10.1	List the excitation methods used, the various types of electrodes used and how the sample is prepared for an emission spectrograph.
Unit 10.2	Explain the operation of an emission spectrograph and its application in both qualitative and quantitative analyses.
Section 11	Explain that the instruments studied thus far have measured certain properties of electrons while NMR is the first one to measure properties of the nucleus of the atom.
Unit 11.1	List the properties of the nucleus that the NMR is measuring and how the measurements are made.
Unit 11.2	Explain the operation of an NMR and how it is used in the field of structure determination and delineation.

Section 12	Explain the theory of mass spectrometry, the instrumentation, its applications and how to evaluate the data obtained.
Unit 12.1	List the principles upon which mass spectrometry is based and the components of the two main types of instruments now in use.
Unit 12.2	Correlate the spectra obtained from the instrument with the structure of the sample.
Section 13	List the disintegration products of radioactive decay, how they interact with matter, the ways they are detected and their applications.
Unit 13.1	Explain the operation of scintillation counters and ionization detectors.
Unit 13.2	Explain how the tagging technique is used in medicine, agriculture, industry and in analytical chemistry to follow the course of a reaction.
Section 14	Explain, with illustrations, the operation of a Cannon-Fenske viscometer and how it is used to determine the molecular weights of polymers.

LABORATORY EXPERIMENTS

1. Analysis of Dyes by Paper Chromatography

Objective: To resolve a mixture of substances known as acid-base indicators to develop facility with the paper chromatography technique.

Five known dyes are observed individually along with an unknown mixture in a solution of ammoniated butanol. The unknown mixture is analyzed by the Rf values.

2. Separation of Pigments by Column Chromatography

Objective: To separate the pigments in spinach leaves; to develop facility with the column chromatography technique. Six large spinach leaves are ground up in a methanol-water mixture. Using petroleum ether and 2,2,4-trimethylpentane the pigments in the leaves are distributed along the column. The phases can be collected for testing on a spectrophotometer.

3. Thin Layer Chromatography of the Products of the Nitration of Bromobenzene

Objective: To determine the purity and relative amounts of the nitration products of bromobenzene; to develop facility with the thin layer chromatography technique.

Bromobenzene is nitrated and m-dinitrobenzene is prepared in the organic lab and the products of these syntheses are tested for purity by the thin layer chromatography technique.

4. Analysis of Nail Polish Remover by Gas Chromatography

Objective: To determine the weight fraction of acetone in a sample of commercial nail polish remover.

A sample of pure acetone is run on the instrument to determine the retention time. With this information the acetone peak can be found on the chromatogram and its weight fraction calculated.

5. Spectrophotometry and Ion Exchange Separation

Objective: To separate cobalt and iron by ion exchange and determine the efficiency of the separation by spectrophotometry. Cobalt chloride hexahydrate and ferric chloride hexahydrate are treated with an anion exchange resin to separate the metallic ions. The two resulting solutions are tested on the spectrophotometer to determine their concentrations by comparing them with known samples.

6. Determination of Hydrogen Peroxide in Bleach

Objective: To determine the amount of hydrogen peroxide in a household bleach by spectrophotometry and to develop the ability to follow complex instructions.

The percent of hydrogen peroxide in a commercial bleach is determined by allowing the hydrogen perioxide to react with potassium iodide in acid solution. The actual measurements are made on the iodine formed as a product of this reaction.

7. Absorption of Beta Rays

Objective: To demonstrate the absorption of a form of radioactivity by matter. A counter is used to detect the amount of beta radiation in the background and then a source is counted. Thin aluminum sheets are used to absorb the radiation.

8. Determination of the Sugar Content of Commercial Syrups

Objective: To determine the sugar content of several syrups and to calculate the relative cost for a quantity of sugar. Also, to develop some facility in working with a refractometer. The refractive indices of various liquid compounds are found on the refractometer and compared with published values to calibrate the instrument. The syrups are then tested and percent sugar is determined by the refractive index.

9. Infrared Spectra of Classes of Organic Compounds

Objective: To find the characteristic functional group frequencies of several classes of organic compounds by inspecting infrared spectra. The student will obtain spectra of assigned organic compounds. Using the spectra along with molecular models he will determine the functional group infrared frequencies of the various types of compounds.

10. Viscosity of Motor Oils

Objective: To determine the significance and meaning of the numbering system used on motor oils by the Society of Automotive Engineers and to develop some facility with a viscometer. Motor oils of various ratings and from different companies are tested for their viscosities at room temperature and elevated temperatures.

11. Determination of the Optical Activity of Various Sugars.

Objective: To determine the concentration of an unknown solution using the polarimeter; to develop facility with the operation of a polarimeter. An unknown sugar solution of known concentration is analyzed on the polarimeter. From the results the sugar can be identified. When the sugar is known determinations of unknown concentrations can be found.

12. A Titrimetric Method for Selective Analysis of Vitamin C with a pH Meter.

Objective: To determine the vitamin C content of various food samples without interference from citric acid; to develop facility at using the pH meter for titrations. The pH meter is used to plot titration curves for vitamin C. These curves are used to determine the vitamin C content of various foods and results are checked with the manufacturer's label.

13. The Determination of the Basicity of an Antacid Using an Automatic Titrator.

Objective: To perform a titrimetric analysis of a commercial product; to develop facility in the use of an automatic titrater.

Commercial antacids such as Tums are analyzed for their basicity. These products are compared with each other for active ingredients and their prices.

14. Decomposition of Various Compounds to Confirm Composition.

Objective: To confirm the composition and formulas of water, hydrogen chloride and ammonia by electrolysis.

Water, hydrogen chloride and ammonia are separated by electrical currents and the resulting gases measured for amounts and properties.

In addition, the aquameter is available for the student who shows interest in automatic titration. This instrument requires experience in electronic methods of titration. It is used in the petroleum industry and in other areas of the chemical industry where the absence or minimization of water is important. Also, the mercury analyzer can be used for experimentation beyond the work done in Environmental Chemistry CH–106.

Most of the preceding laboratory experiments are adapted from published sources. The following is a list of these sources, along with some others that may prove helpful.

Experiment 1: Cherim, S.M., *Laboratory Manual for Technicians,* W. B. Saunders Co., Philadelphia, 1971, p.47
An alternate or supplementary experiment is found in: Kenner, C. T., *Laboratory Directions for Analytical Separations and Determinations,* The Macmillan Company, New York, 1971, p.115

Experiment 2: Cherim, S. M., op. cit., p. 53, An experimental procedure which may be helpful is found in Clark, A. K., & Bell, Jr., C. E. *Laboratory Experience in Organic Chemistry,* Charles E. Merrill Publishing Co., Columbus, Ohio, 1972, p. 51.

Experiment 3: *Modern Chemical Technology,* A Chemical Technician Curriculum Project of the American Chemical Society, Washington, D. C., 1970, First Edition, Volume 5, p. 31–48

Experiment 4: Modern Chemical Technology, op. cit., Volume 1, p. 4–5

Experiment 5: Cherim, op. cit., p. 167, Alternate or supplementary experiments are found in: Kenner, op. cit., p. 101 and Modern Chemical Technology, op. cit. Volume 2, p. 10–2.

Experiment 6: Modern Chemical Technology, op. cit., Volume 7, p. 48–10.

Experiment 7: Modern Chemical Technology, op. cit., Volume 9, p. 71–2, Cherim, S. M., op. cit. p. 151

Experiment 8: Modern Chemical Technology, op. cit., Volume 7, exp. 49–3

Experiment 9: Modern Chemical Technology, op. cit., Volume 5, exp. 30–1

Experiment 10: Instructor prepared experimental procedure.

Experiment 11: Modern Chemical Technology, op. cit., Volume 6, exp. 39–1.

Experiment 12: Modern Chemical Technology, op. cit., Volume 7, exps. 43–2 and 43–3. Other experimental procedures which may be found helpful as introductory or supplementary work are: Cherim, S. M., op. cit., p. 91 and p. 101, Kenner, op. cit., p. 23 and Clark and Bell, Jr., op. cit., p. 63

Experiment 13: Modern Chemical Technology, op. cit., Volume 4, exp. 25–3.

Experiment 14: Instructor prepared experimental procedure.

The course is taught as a combination of lecture and laboratory experiments. The lectures cover theoretical aspects of organic chemistry which are a continuation of CH–201. The lectures are of an informal nature, where the student is encouraged to participate by asking questions and by explaining his solutions of problems to the class. Reading material is assigned to prepare the student for the lectures and problems. Other assignments such as library research are made to reinforce or add to the original lecture.

The text books, references and periodicals listed in this syllabus are available either in the lab, from the instructor, or from the school library. It may sometimes be necessary to prepare "Information Sheets" if it is felt that the text does not cover the subject adequately.

Guest lecturers are invited to lend expertise on particular subjects. Films and slides are shown where they are deemed appropriate and are available. Charts, graphs, pictures and cartoons can and should be collected and used when needed during the presentation of the lectures.

In general, the laboratory experiments are concurrent with the lectures. They are performed on an individual basis. Demonstrations to the entire class are given when appropriate, but more often the instructor will demonstrate a proper procedure to an individual student who may be having difficulty. Close supervision of the students' work is necessary both for reasons of safety and for the development of proper techniques.

TEXTBOOKS

The textbooks for Chemistry 201 and 202 are:

1. *Organic Chemistry:* A short Course, H. Hart and R. D. Schuetz, Fourth Edition, Houghton Mifflin Co., 1972.
2. *Experimental Organic Chemistry*, C. A. MacKenzie.

EVALUATION OF STUDENTS CH–202

The students are evaluated on their test results, laboratory performance, laboratory proficiency, laboratory notebook, homework assignments, professional attitude and class participation. A composite grade of 70% would be necessary for them to receive a letter grade of "C" for the course.

1. **Tests:**

Three tests, including the final examination, are given during the course at the times specified. At least one test will consist of a practical problem. The grade will be based upon the instructor's observation of the behavioral objectives. Unannounced quizzes may be given at any time. A quiz could be anything from a single problem or essay taking 10 minutes up to what might be considered an extra test. After the first test, each student is individually counseled concerning his progress to that point. His performance is discussed and if improvement is required, he is informed of his deficient areas and what is expected of him in order to receive at least a "C" grade for the course. For students who are not making much progress, counseling is necessary before this point. Tests and quizzes are devised in such a way as to reflect the attainment of the objectives of the course. A student who averages 90 or better will get an "A" for the course. A grade of 75 to 90 would be in the "C" to "B" range. A student scoring between 60–75 needs extra help before continuing, and one who scores less than 60 is in danger of failing the course.

Written tests will be given after the following points in the outline:

Test # 1	After Section 2	1 hour
Test # 2	After Section 4	1 hour
FINAL EXAMINATION		1½ hours

2. **Laboratory Performance:**

A rating sheet for lab performance is included as an appendix. It is filled out at least twice during the quarter for each student and more frequently if there is any observable improvement or deterioration in a student's performance. If a student gets 125 or better out of a maximum 155 points, he is doing an excellent job in the lab. A score of 100 to 125 indicates that there are some areas that need improvement. When the score is below 100, the instructor should give the student individual counseling to discuss his chances of passing the course.

3. **Laboratory Proficiency:**

Manual ability is evaluated by observation of such operations as:

a. Making measurements – For volumes this includes filling and partially emptying volumetrically calibrated equipment like cylinders and burets and reading the bottom of the meniscus accurately. For weights choosing the proper balance for the job, adjusting it to its zero position, and using the balance gently to avoid sudden jars to its delicate mechanism.

b. Filtering – Most filtering in the organic lab is performed with a Buchner funnel and vacuum. Proper setting of the filter paper in the funnel, proper control of the vacuum, pouring to prevent overflow and careful removal of the paper and the filtered solid are points to be observed.

c. Washing glassware thoroughly – To avoid possible contamination.

d. Transferring – Transferring chemicals from one container to another without spilling or causing contamination. Special emphasis is placed on observing the dispensing of small amounts of liquids with medicine droppers.

e. Setting up apparatus according to instructions – With special emphasis on the prevention of a closed system. Glass bends, when used, should be properly made to prevent safety hazards.

f. The proper use of a separatory funnel – When this piece of equipment is used with a volatile liquid it must be vented with every rotation to prevent its bursting from built up pressure.

g. Setting up a distillation apparatus – Here the student must go through a check list for proper operation.

h. Handling hazardous chemicals – Handling chemicals such as sodium metal, calcium carbide and others in a safe manner.

i. Heating flasks – Use electric heating mantles and only use flames when instructed.

j. In general – Observations are made as to how well the student follows instructions. The student will also be questioned frequently to evaluate his ability to relate theory to practice in the laboratory.

k. It should be noted that a more critical evaluation will be made of the student's performance in the laboratory during this semester since he has already completed a semester of work in the organic laboratory.

4. **Laboratory Notebook:**

The notebook is a record of the student's work in the lab and should be kept up to date. A delay between performance and recording usually results in a lower grade and making notes and calculations any place but the notebook is discouraged. The notebook should contain for each experiment:

A. Title of experiment
b. Dates of performance and completion
c. A statement as to the purpose of the experiment
d. Equations
e. A qualitative description of the procedure followed with observations.
f. Amounts of materials used in a tabular form
g. Data collected and yield calculations in a tabular form.
h. Observed or determined properties of the product (color, physical state, melting point, boiling point, etc.)
i. Alternative methods of preparation.
j. Answers to questions asked in the manual or supplied by the instructor.
k. Personal comments or suggestions for improvement.

No specific format is required, but the student will be graded on neatness, completeness and accuracy of results. If the student does not get the desired result, he can improve his grade by including a section in his report giving possible reasons for his incorrect result. The notebooks are collected and graded about every 10 days.

5. Homework Assignments:

Homework problems are assigned but not collected. Instead, students are selected at random to present their solutions to the class and are given grades for their presentation. Any homework problem which was found difficult by the entire class is explained by the instructor.

6. Professional Attitude:

This is a subjective evaluation on the part of the instructor of those aspects of a student's character which will have a bearing on his ability to perform successfully as a chemical technician.

7. Class Participation:

The student is evaluated for his participation in and contributions to class discussions, answering the instructor's questions, asking pertinent and relevant questions and also by a random evaluation of lecture notes.

Objective:

To write the equations for the preparation of Nylon 66 and for other similar derivatives of diamines.

Preparation:

1. Textbook (Chapter 12, pages 286–290.)
2. Lab Manual (Experiment 43, page 233.)

Introduction:

Since Nylon is a household word being used to manufacture fabrics, carpets, rope, sweaters, stockings and many molded objects, it would be helpful if we knew just how it is made.

Connection with Previous Lesson:

We have studied many compounds with one amine group. With this as a background we can proceed to compounds with two amine groups (Diamines) which are used to make various polymers.

Presentation:

Demonstration lecture, discussion and sample problems.

Teaching Points:

1. Preparation of ethylene diamine
2. Hexamethylene diamine
3. Polyamide
4. Can be drawn when molten
5. The meaning of 66
6. Adipic acid
7. Caprolactam

Homework:

1. Read pages 290–294.
2. Problem 17 in text.

ORGANIC CHEMISTRY II CH–202

Fourth Semester: First 6 weeks of the semester
Lecture: 4 hours per week
Laboratory: 6 hours per week
Credits: 2

This is the final course in the core program sequence. It is given during the first 6 weeks of the semester which allows time for the field project during the last 10 weeks of the semester. The course consists of 24 hours of lecture and demonstration (4 hours per week) and 36 hours of laboratory work (6 hours per week). Arrangements are made for a final exam. It is a 2 credit course.

The lectures are a continuation of those in Organic Chemistry I, with an emphasis on topics which are helpful for environmental studies. The topics include fats, oils, waxes, detergents, amines, amino acids, proteins, carbohydrates, vitamins, hormones, antibiotics and drugs.

The laboratory work in this course includes the study of the properties of organic chemicals which come into contact with living cells. Some biologically important compounds will either be synthesized or their properties will be studied. These will include sugars, nicotine, caffeine and antibiotics.

COURSE OBJECTIVES

The objectives of this course are to:

1. Develop the ability to correctly assemble the pieces of apparatus used in an organic chemistry laboratory.
2. Keep all apparatus clean and in its proper place so that it is always ready.
3. Take all necessary safety precautions in the laboratory by recognizing and anticipating potential hazards.
4. Correctly select the equipment and chemicals for the particular experiment.
5. Develop the ability to anticipate the effect that a change in conditions could have on the outcome of an experiment.
6. Explain the laws and theories which govern the way a reaction proceeds.
7. Develop the necessary skills for neatness, accuracy and completeness in the recording of data.
8. Keep an up-to-date notebook which includes all the relevant data for each experiment attempted.
9. Research the literature to prepare for an experiment or when new problems are encountered.
10. Maintain the laboratory in a clean, safe and orderly manner to insure efficiency.

CAREER OBJECTIVES

The student will be able to:

1. Apply knowledge of chemistry in giving direct technical assistance to chemists engaged in organic research and experimentation.
2. Develop, design or plan modification of new products, techniques and processes under the supervision of a chemist in applied chemical or related research.
3. Assume responsibility for performance tests of: chemical apparatus, determinations, tests, analyses of substances; and the preparation of appropriate technical reports covering the tests.
4. Communicate in the language of organic chemists and be able to comprehend instructions for proper performance in the organic laboratory.
5. Function as an essential member of the organic chemistry research and production team.
6. Perform his duties and display a broad understanding of organic chemistry to insure rapid advancement, both financially and in job responsibilities.
7. His ability to work with environmental chemists is strengthened by this course.

TOPICAL OUTLINE

LECTURE		24 HRS.
Section 1	Fats, Oils, Waxes and Detergents	4 hrs.
Unit 1.1	The structure and reactions of fats and oils	
Unit 1.2	The preparation and cleaning action of soaps and detergents	
Unit 1.3	Waxes and the analysis of fats and oils	
Unit 1.4	The metabolism of fats	
Section 2	Amines and Diazonium Compounds	5 hrs.
Unit 2.1	Nomenclature and general characteristics of amines	
Unit 2.2	Preparation and reactions of amines	
Unit 2.3	Nylon and diamines	
Unit 2.4	Heterocyclic amines	
Unit 2.5	Aromatic diazonium compounds	
Section 3	Carbohydrates	4 hrs.
Unit 3.1	Classification of carbohydrates	
Unit 3.2	Reactions of monosaccharides	
Unit 3.3	Disaccharides	
Unit 3.4	Polysaccharides	
Section 4	Amino Acids and Proteins	6 hrs.
Unit 4.1	Naturally occurring amino acids	
Unit 4.2	Properties and analysis of amino acids	
Unit 4.3	Amino acid syntheses	
Unit 4.4	Peptides	
Unit 4.5	Protein structure	
Unit 4.6	Proteins and their metabolism	
Section 5	Natural Organic Products	5 hrs.
Unit 5.1	Terpenes	
Unit 5.2	Steroids	
Unit 5.3	Biosynthesis of terpenes and steroids	
Unit 5.4	Oxygen and nitrogen heterocycles	
Unit 5.5	Nucleic acids, RNA and DNA	

OBJECTIVES OF CH–202 LECTURES

The student will be able to:

Section 1 A. Write equations for the saponification, hydrogenation and hydrogenolysis of a typical fat.

B. Explain, with equations, the mechanism of cleaning with soaps and detergents.

C. Explain, with equations, the metabolism of fats.

Unit 1.1 Write the structural formulas of fats and oils and equations for their important reactions.

Unit 1.2 Explain, with the help of an equation, why ordinary soaps do not work satisfactorily in hard water and how synthetic detergents overcome this defect.

Unit 1.3 Calculate an iodine number and determine the number of double bonds per fat molecule.

Unit 1.4 Write out the steps in a biological conversion of one carboxylic acid to another.

Section 2 A. Classify and write structural formulas and equations for the preparation and reactions of amines.

B. Identify and give uses for some heterocyclic amines, and diazonium compounds.

Unit 2.1 Classify amines as to primary, secondary and tertiary and explain, with equations, their basicity.

Unit 2.2 Devise syntheses for the preparation of an amine and for a derivative from an amine.

Unit 2.3 Write the equations for the preparation of Nylon 66 and for other similar derivatives of diamines.

Unit 2.4 Identify some heterocyclic amines and list their uses, either alone or in the synthesis of other products.

Unit 2.5 Write equations for the preparation of diazonium salts with emphasis on the production of dyes.

Section 3 Define, explain or give structural formulas for the new words and terms introduced in this section.

Unit 3.1 Classify carbohydrates as to mono, di-, oligo-, and polysaccharides.

Unit 3.2 Explain, with equations, the reducing action of monosaccharides and the preparation of osazones and glycosides.

Unit 3.3 List the important disaccharides with their structural formulas.

Unit 3.4 List the important polysaccharides such as starch and cellulose with their structural formulas.

Section 4 A. List 10 of the most common amino acids with structural formulas. Write equations for their preparation.

B. Explain in essay form how amino acids and proteins are used in the human body.

Unit 4.1 Classify amino acids as to whether they are essential or not, and by the number of amino groups and carboxyl groups.

Unit 4.2 Outline the analysis of an amino acid by the ninhydrin reaction.

Unit 4.3 Write equations for two methods of preparing amino acids and for four important reactions.

Unit 4.4 Explain how peptides are formed from the partial or incomplete hydrolysis of proteins.

Unit 4.5 Explain, with the use of illustrations, the primary, secondary, tertiary and quaternary protein structures.

Unit 4.6 Write two short essays. One on the metabolism of proteins, and one on the place of amino acids and proteins in the evolution of life.

Section 5 Write an essay on how organic chemists have isolated, determined the structures of and synthesized the active ingredients of such things asplants and then synthesized new compounds with improved properties over those found naturally.

Unit 5.1 Explain the carbon linkages in the terpenes with emphasis on menthol, camphor and vitamin A.

Unit 5.2 Write the common structural features of steroids with emphasis on cholesterol, sex hormones, oral contraceptives and the D vitamins.

Unit 5.3 Explain, with equations, how nature synthesizes the terpenes and steroids.

Unit 5.4 Identify some oxygen and nitrogen heterocycles, with emphasis on vitamin C, nicotine, novacaine, morphine, reserpine, caffeine, the B vitamins, penicillin and chlorophyll.

Unit 5.5 Draw a segment of an RNA chain, with four nucleotide units, each different and name each part of the structure.

LABORATORY EXPERIMENTS CH–202

Lab Manual: *Experimental Organic Chemistry* by C. A. MacKenzie, Third Edition, Prentice-Hall, Inc., 1967.

Experiment Number	Manual Number	Title of Experiment	Hours
1	22	Introduction to Qualitative Organic Analysis	9
2	34	Qualitative Organic Analysis	9
3	40	Replacement and Coupling Reactions with Diazonium Salts	6
4	47	Carbohydrates, Monosaccharides and disaccharides	6
5	48	Preparation of Heterocyclic Compounds	6
			36

LABORATORY OBJECTIVES

The student will be able to:

Experiment 1: Identify unknown organic compounds which have been used in the lab work using a properties-matching process.

Experiment 2: The same as Experiment 1 with compounds that are more difficult to identify.

Experiment 3: Perform replacement and coupling reactions with diazonium salts including use of the Sandmeyer reaction.

Experiment 4: Perform test procedures on sugars to identify them.

Experiment 5: Prepare two heterocyclic compounds whose derivatives are of medicinal value. One of them is used for the treatment of epileptic seizures.

This is primarily a lecture course. The instructor will lecture on a particular topic and assign questions and problems for the next class meeting. Demonstrations by the instructor and demonstrations with student participation are a part of many of the lectures.

Reading material is assigned to prepare the student for the lectures and library research is also included to reinforce or add to the lectures.

Appropriate films and slides are shown. Charts, graphs and diagrams are frequently used during the lecture presentation. These are distributed to the students or shown on the overhead projector.

TEXTBOOKS

The textbook for Chemistry 225 is:

1. *Fundamentals of Physical Chemistry,* H. D. Crockford and S. B. Knight, John Wiley & Sons, Inc., Second Edition, New York, N. Y., 1967.

EVALUATION OF STUDENTS CH–225

The students are evaluated on their test results, homework assignments, professional attitude and class participation as follows:

Test results	40%
Final Exam	25%
Homework	15%
Class participation	10%
Professional attitude	10%
	100%

A composite grade of 70% would be necessary for a student to receive a letter grade of "C".

1. Tests:

Five tests, including the final examination are given during the course at the times specified. Unannounced quizzes may be given at any time. A quiz counts half as much as a test, since the student has not specifically prepared for it. After the second test, each student is individually counseled concerning his progress to that point. His performance is discussed and if improvement is required he is informed of his deficient areas and what is expected of him in order to receive at least a "C" grade for the course. For the students who are not making much progress, counseling is necessary before this point. Tests and quizzes are devised in such a way as to reflect the attainment of the objectives of the course. A student who averages 90 or better will get an "A" for the course. A grade of 75 to 90 would be in the "C" to "B" range. A student scoring between 60 to 75 needs extra help before continuing and one who scores less than 60 is in serious danger of failing the course.

Written tests will be given after the following points in the outline:

Test # 1	After Section 4	1 hour
Test # 2	After Unit 6.2	1 hour
Test # 3	After Section 7	1 hour
Test # 4	After Section 10	1 hour
FINAL EXAMINATION		1½ hours

2. Homework assignments:

Homework problems are assigned but not collected. A random survey is made to determine if the homework has been attempted by the student. Students are selected to present their solutions to the class and are given grades for their presentation. Any homework problem which was found difficult by the entire class is explained by the instructor.

3. **Class participation:**

The student is evaluated for his participation in and contributions to class discussions, answering the instructor's questions and also by a random evaluation of lecture notes.

4. **Professional Attitude:**

This is a subjective evaluation on the part of the instructor of those aspects of a student's character which will have a bearing on his ability to perform successfully as a chemical technician.

Objective:

To calculate heat changes for reactions using Hess's Law of Heat Summation.

Preparation:

Reading assignment: pages 82–86 in textbook
Appropriate slides from the set on equilibrium

Introduction:

How can a heat of formation be determined if it cannot be easily carried out calorimetrically?

Connection with previous lesson:

We have shown how a calorimeter is used to determine a heat of reaction. We will now discuss a law developed by Hess which states that the heat change in a particular reaction is always constant and is independent of the manner in which the reaction takes place.

Presentation:

Lectures with slides, and blackboard examples and illustrations.

Teaching Points:

1. The statement of Hess's Law
2. Examples to illustrate its validity
3. Writing the thermochemical equations
4. Care in the proper use of positive and negative signs for H.

Classwork:

Question 6 and Problems 3 & 5 on page 87 in textbook

Homework:

Problems 4, 7, & 8 on page 88 in textbook.

LABORATORY PERFORMANCE RATING SHEET

CATEGORY

poor---excellent

RATING

SAFETY	1	2	3	4	5
1. Wears goggles					
2. Uses towel when breaking glass					
3. Fire polishes all glass tubing and bends					
4. Wears protective clothing					
5. Knows safety equipment location					
6. Works only with assigned partner					
7. Works only at assigned station					
8. Observes all safety regulations					
9. Observes rules of good conduct					
10. Follows instructions carefully and precisely.					

LABORATORY TECHNIQUES					
1. Pours from reagent bottles properly					
2. Leaves stock bottles closed					
3. Signs out for all extra equipment					
4. Is neat in obtaining stock reagents					
5. Returns equipment promptly and well-cleaned					
6. Disposes of excess reagents as instructed					
7. Uses filtration apparatus properly					
8. Has functional knowledge of operation of basic laboratory equipment.					
9. Collects data in an orderly fashion					
10. Exhibits knowledge of basic laboratory techniques					

GENERAL: PROCEDURE, ORDER, ATTITUDE					
1. Station generally neat					
2. Table top clean and free from reagents					
3. Glassware cleaned after each use					
4. Personal locker in order					
5. Table and station area free from paper and debris					
6. Scale on lock, all weights at zero					
7. Exhibits knowledge of purpose of experiment					
8. Works directly toward goal of experiment					
9. Shows real effort and scientific attitude toward lab work					
10. Refrains from unnecessary talking and horseplay.					
11. Does not annoy others when finished himself					

NAME ______________________________ **DATE** __________

EXPERIMENT ______________________ **EVALUATION** __________

OVERALL RATING ______________________________

PHYSICAL CHEMISTRY CH–255

Fourth Semester: 16 Weeks
Lecture: 3 hours per week
Credits: 3

Physical Chemistry is a fourth semester course in a two-year program in chemical and environmental techonology. It consists of 48 hours of lecture and demonstration (3 hours per week) for 16 weeks. The final exam is given during the 16th week. It is a 3 credit course.

Physical chemistry may be defined as the branch of chemistry concerned with the physical properties and structure of matter and with the laws and theories of physical and chemical changes. Since it makes use of many of the concepts of physics, it is necessarily placed into a curriculum after the student has completed his Physics courses.

Most of the topics in the course have been studied in previous courses. In this course, greater depth is achieved by combining the concepts of chemistry and physics.

TOPICAL OUTLINE

LECTURE		48 HRS.
Section 1	Introduction	1
Section 2	Gases	3
Unit 2.1	The kinetic theory	
Unit 2.2	Deviations from the ideal gas law	
Section 3.	Liquids	4
Unit 3.1	Vapor pressure	
Unit 3.2	Surface tension	
Unit 3.3	Viscosity	
Section 4.	Basic Thermodynamics	6
Unit 4.1	Forms of energy and the first law	
Unit 4.2	Enthalpy	
Unit 4.3	Reversible processes	
Section 5	Thermochemistry	4
Unit 5.1	Definitions and classification	
Unit 5.2	The Determination of heats of reaction	
Unit 5.3	Hess's Law	
Unit 5.4	Variation of AH with temperature	
Section 6	Solutions	6
Unit 6.1	Solutions of liquids in liquids	
Unit 6.2	Solutions of solids in liquids	
Unit 6.3	Osmotic Pressure	
Unit 6.4	Modern ionic theory	
Unit 6.5	Acid-base theory	
Section 7	Chemical equilibrium	4
Unit 7.1	Reversible reaction concept	
Unit 7.2	Applications	
Unit 7.3	LeChatelier's principle	
Section 8	Entropy and free energy	3
Unit 8.1	The concept of entropy	
Unit 8.2	The concept of free energy	
Section 9	Conductivity	3
Unit 9.1	Terms and units	
Unit 9.2	Electrode reactions	
Unit 9.3	Measurement of conductance	

		48 HRS.
Section 10	Electromotive force	3
Unit 10.1	The Galvanic cell	
Unit 10.2	The measurement of cell potentials	
Unit 10.3	The thermodynamics of galvanic cells	
Section 11	Reaction kinetics	5
Unit 11.1	Reaction order	
Unit 11.2	Catalysis	
Section 11	Adsorption	3
Unit 12.1	The process of adsorption	
Unit 12.2	Types of adsorption	
Section 13	Colloidal systems	3
Unit 13.1	Definitions and classification	
Unit 13.2	Sols	
Unit 13.3	Emulsions	

FINAL EXAMINATION

OBJECTIVES OF CH–225 LECTURES

The student will be able to:

Section 1 Define, in writing, the various terms and units that will be used in the course.

Section 2 Correctly answer questions about the gas laws, their effect on the behavior of matter in the gaseous state and the kinetic theory.

Unit 2.1 State the postulates of the kinetic theory and develop the kinetic equation from the postulates.

Unit 2.2 Continuing from the previous objective, the student will be able to point out the inconsistencies of the kinetic theory and show how the Vander Waals' constants help to correct them.

Section 3 Determine from tables or from calculations the vapor pressure, surface tension and viscosity of liquids and to describe some of the equipment used to find this information by experimentation.

Unit 3.1 Define vapor pressure. Describe how vapor pressure changes with temperature, how it is found experimentally, and perform calculations using the vapor pressure.

Unit 3.2 Define surface tension. List three manifestations of surface tension and tell why they take place. Describe in detail the determination of surface tension.

Unit 3.3 Define viscosity. Distinguish between relative and absolute viscosity and describe in detail the experimental determination of viscosity by means of an Ostwald viscosimeter.

Section 4 Match 20 words, phrases and symbols used in basic thermodynamics with their correct definitions.

Unit 4.1 Name several forms of energy and list the ways they differ from each other. Write a short essay on some application of the first law of thermodynamics.

Unit 4.2 Perform calculations using enthalpy and internal energy.

Unit 4.3 Write an essay on the concept of reversibility, its importance and some of its characteristics.

Section 5 State, in writing, the relationship between the heat of reaction at constant volume and constant pressure. Calculate heats of reaction from heats of formation and calculate heats of reaction at various temperatures.

Unit 5.4	Calculate the heat of formation at T_2 when the data is given for T_1.
Section 6	State, in essay form, the nature and properties of solutions and show how the laws that describe their behavior were developed.
Unit 6.1	Calculate six different ways of expressing the concentration of a solution from the data used in its preparation.
Unit 6.2	Calculate the composition of vapor in equilibrium with a solution at a given temperature using Raoult's Law.
Unit 6.3	Describe, in writing, how osmotic pressure is determined, the cause and mechanism of osmotic flow and how osmotic pressure is calculated.
Unit 6.4	List the facts that the Arrhenius theory can explain and those which can only be explained by the modern ionic theory.
Unit 6.5	State, in writing, how the Bronsted-Lowry theory defines acids and bases.
Section 7	Describe, in writing, how the equilibrium constant expression can be simply derived from kinetic considerations.
Unit 7.1	Calculate an equilibrium constant for a reversible reaction using given concentration data.
Unit 7.2	Determine in which direction a reaction proceeds and the moles of each substance present at equilibrium in a reaction mixture.
Unit 7.3	Write a short essay on how according to LeChatelier's principle, concentration, temperature and pressure changes affect an equilibrium mixture.
Section 8	Write an essay on entropy, free energy and the third law of thermodynamics, emphasizing their significance in chemical reactions.
Unit 8.1	Calculate entropies for isothermal change of state and for the isothermal expansion of a gas.
Unit 8.2	Calculate free energy changes for chemical reactions such as solubility products, decomposition of gases and ionization.

Section 9	Describe, in writing, the phenomena associated with the conductance of electricity through aqueous solutions of electrolytes. This should include a consideration of electrode reactions and the relation between the quantity of current passing through the solution and the quantity of products formed at the electrodes.
Unit 9.1	Match 20 words, terms and symbols with their proper definitions.
Unit 9.2	Determine over-all reactions from half reactions and perform calculations using Faraday's laws.
Unit 9.3	Calculate cell constants from the observed conductance and specific conductance.
Section 10	Describe, in writing and with diagrams, the galvanic cell and its place in the study of physical chemistry. Determine if a particular reaction is spontaneous.
Unit 10.1	List the characteristics that a chemical reaction must possess in order for its reactants and products to be useful in a galvanic cell.
Unit 10.2	Explain, in detail, the operation and use of a potentiometer in measuring cell potentials.
Unit 10.3	List the three general thermodynamic equations used in the study of galvanic cells and tell just how they are used.
Section 11	Describe, in writing, the techniques used in reaction kinetic studies including: reaction order, catalytic action and activation energy.
Unit 11.1	Identify the order of a reaction and calculate its velocity constant.
Unit 11.2	List several examples of catalytic processes, both heterogeneous and homogeneous, taking place in both the liquid and gaseous states.
Section 12	List the factors determining the extent of adsorption at various types of interfaces and the theories explaining its mechanism.
Unit 12.1	Describe, in writing, the process of adsorption including some samples.
Unit 12.2	List the two main types of adsorption and the mechanism for each type.
Section 13	Describe, in detail, the difference between colloidal systems and true solutions and the differences between sols, emulsions, foams, aerosols and gels.
Unit 13.1	Prepare a table listing the types of colloidal systems, the dispersed phase and the dispersion medium, the type of system produced and an example of each type.

Unit 13.2 Classify sols from the standpoint of the dispersion medium, and describe the condensation method for preparing a sol.

Unit 13.3 Describe in writing, how an emulsion is prepared with emphasis on the role of the emulsifying agent.

GENERAL REFERENCES FOR THE PROGRAM

1. *Handbook of Chemistry and Physics*, Editor-in-Chief, R. C. Weast, 53rd and subsequent editions, 1972–1973, CRC Press, a division of the Chemical Rubber Co., Cleveland, Ohio.
2. *Lange's Handbook of Chemistry*, Editor N. A. Lange, Revised Tenth Edition, 1967, McGraw Hill Book Co., New York.
3. *The Merck Index*, Editor P. G. Stecher, Merck and Co., Inc., Rahway, N.J., 8th Edition, 1968.
4. *Kingzeh's Chemical Encyclopedia*, General Editor D. H. Hey, Bailliere, Tindall and Casell Ltd., London, England, 9th edition, 1966.
5. *International Encyclopedia of Chemical Science*, by an editorial group, D. Van Nostrand Co., Inc., Princeton, N. J., 1st edition, 1964.
6. *The Condensed Chemical Dictionary*, edited by A. Rose and E. Rose, Reinhold Book Corp., New York, 7th Edition, 1966.
7. *Modern Chemical Technology*, 10 volumes, R. L. Pecsok, Project Director of Writing team, A project of the American Chemical Society and published by the Society in its first edition in 1970.

*8. *Pharmacopeia of the United States*, Mach Publishing Co., Easton, Pa.

9. *Chemical Abstracts, Organic and Physical Chemistry Sections*, American Chemical Society, Easton, Pa. – April, 1963 to December 1968.
10. *ASTM Standards*, American Society for Testing Materials, Philadelphia, Pa.
11. *Searching the Chemical Literature*, Editor R. F. Gould, American Chemical Society, Easton, Pa.

REFERENCE TEXTS FOR THE PROGRAM

These texts are listed in the order in which they will be most helpful as the program progresses.

1. *Vitalized Chemistry*, H. Dolin, 7th edition, 1970, College Entrance Book Co., New York.
2. *Chemistry – An Investigative Approach*, F. A. Cotton and C. D. Lynch, 1st edition, 1968, Houghton-Mifflin Co.

3. *Basic Principles of Chemistry*, E. C. Winslow, 1962, D. Van Nostrand & Co., Inc., Princeton, N. J.

4. *Principles of Chemistry*, J. H. Roe, 10th edition, 1967, The C. V. Mosby Co., Saint Louis, Mo.

5. *Problems for General Chemistry and Qualitative Analysis*, G. J. Nyman and G. B. King, 1st edition, 1966, John Wiley and Sons, Inc., New York

6. *Chemistry – An Experimental Science*, Editor G. C. Pimentel, 1st edition, 1963, CHEM study text, W. H. Freeman & Co., San Francisco, California.

7. *G[illegible]al Chemistry*, J. A. Timm, Fourth edition, 1966, McGraw-Hill Book Co., New York.

8. *Semimicro Qualitative Analysis*, P. Arthur and O. M. Smith, Third edition, 1952, McGraw-Hill Book Co., N. Y.

9. *Experimental Procedures in Elementary Qualitative Analysis*, E. S. Gilreath, McGraw-Hill Book Co., N. Y.

10. *Introductory Quantitative Chemistry*, A. R. Olson , C. W. Koch, G. C. Pimentel, 1st edition, 1956, W. H. Freeman and Co., San Francisco, California.

11. *Environmental Pollution*, a guide to the study of. Editor W. A. Andrews, 1st edition, 1972, Prentice-Hall, Inc., Englewood Cliffs, N. J.

12. *Air and Water Pollution*, G. Leinwand and G. Popkin, Washington Square Press, a division of Simon and Schuster, Inc., New York, 1969.

13. *The Environment, A National Mission for the Seventies*, by the Editors of Fortune, Perennial Library, Harper and Row, Inc., New York, 1970.

14. *Chemistry and the Environment*, a special report reprinted from Chemical and Engineering News, American Chemical Society Publications, Washington, D. C., 1967.

15. *Environmental Careers*, O. Fanning, New York Vocational Guidance Manual, 1971.

16. *Environmental Chemistry*, S. Manahan, Willard Grant Press, Inc., Boston, Mass., 1972.

17. *The Environmental Handbook*, Compiler G. DeBell, Ballantine Books, New York, 1970

18. *Career Education in the Environment*, a handbook produced for the United States Office of Education, Division of Vocational and Technical Education, Contract OEG–0–71–4462 (357) by Olympus Research Corp., Washington, D. C.

19. *Organic Chemistry*, L. P. Fieser and M. Fieser, Reinhold Publishing Co., 1956.

20. *Elements of Organic Chemistry*, J. H. Richards, D. J. Cram and G. S. Hammond, McGraw Hill, 1967.

21. *Principles of Modern Organic Chemistry*, J. Cason, Prentice-Hall, 1966.

22. *Principles of Organic Chemistry*, J. English, Jr., H. G. Cassidy and R. L. Baird, McGraw-Hill, 1971.

23. *Introduction to Organic Chemistry*, C. H. DePuy and K. L. Rinehart, Jr., John Wiley and Sons, 1967.

24. *Analytical Determinations and Separations:* A Textbook in Quantitative Analysis, by C. T. Kenner and R. E. O'Brien, The MacMillan Co., New York, First Edition, 1971.

25. *Physical and Chemical Methods of Separation*, by E. W. Berg, McGraw-Hill Book Company, New York, 1st edition, 1963.

26. *Instrumental Analysis Manual*, by G. G. Guilbault and L. G. Hargis, Marcel Dekker, Inc., New York, 1st edition, 1970.

27. *Elementary Electrochemistry*, by A. R. Denaro, Butterworth and Co., Ltd., Washington, D. C., 1st edition, 1965.

28. *Elementary Principles of Laboratory Instruments*, by L. W. Lee, the C. V. Mosby Co., St. Louis, 2nd edition, 1970.

29. *Modern Methods of Chemical Analysis*, by R. L. Pecsok and L. D. Shields, John Wiley and Sons, Inc., New York, 1st edition, 1968.

30. *Chemical Applications of Radioisotopes*, by H. J. M. Bowen, Methnen & Co., Ltd., London, England, 1st edition, 1969.

31. *Separation Techniques in Chemistry and Biochemistry*, edited by R. A. Keller, Marcel Dekker, Inc., 1st edition, 1967.

32. *Chemical Separation Methods*, by J. A. Dean, Van Nostrand Reinhold Co., New York, 1st edition, 1969.

33. *Instrumental Methods of Chemical Analysis,* by G. W. Ewing, McGraw-Hill Book Company, New York, 3rd edition, 1969.

34. *Infrared Spectroscopy,* by R. T. Conley, Allyn and Bacon, Inc., Boston, 1st edition, 1972.

35. *Identification of Organic Compounds,* by N. D. Cheronis and J. B. Entrikin, Interscience Publishers, Inc., New York, 1st edition, 1963.

36. *Chemical Instrumentation* by H. A. Strobel, Addison-Wesley Publishing Co., Inc., Reading,Mass., 1st edition, 1960.

37. *Instrumental and Separation Analysis,* by C. T. Kenner, Charles E. Merrill Publishing Co., Columbus, Ohio, 1st edition, 1973.

38. *Laboratory Manual for Technicians,* S. M. Cherim, W. B. Saunders Co., Philadelphia, Pa., first edition, 1971.

39. *Laboratory Directions for Analytical Separations and Determinations* by C. T. Kenner, the Macmillan Co., New York, first edition, 1971.

40. *Laboratory Experience in Organic Chemistry,* by A. K. Clark and C. E. Bell, Jr., Charles E. Merrill Publishing Co., Columbus, Ohio, 1st edition, 1972.

41. *Experiments for Instrumental Methods,* by C. N. Reilley and D. T. Sawyer, McGraw-Hill Book Company, 1st edition, 1961.

42. *Colorimetric Metal Analysis,* by E. B. Sandell, Volume III of Chemical Analysis, a series of monographs on analytical chemistry and its applications from Interscience Publishers, Inc., New York, 3rd edition, 1959.

43. *Guide to Modern Methods of Instrumental Analysis,* by T. H. Gouw, John Wiley & Sons, Inc., New York, 1st edition, 1972.

44. *Introductory Mass Spectrometry,* by S. R. Shrader, Allyn and Bacon, Inc., Boston, 1st edition, 1971.

45. *Spectral Analysis,* by J. A. Blackburn (editor), Marcel Dekker, Inc., New York, 1st edition, 1970.

46. *Practical Hints on Absorption Spectrometry,* by J. R. Edisburg, Plenum Press, New York, 1st edition, 1966.

47. *The Practice of Gas Chromatography,* edited by L. S. Ettre and A. Zlatkis, Interscience Publishers, Inc., 1st edition, 1967.

48. *Magnetic Resonance Spectroscopy*, by H. G. Hecht, John Wiley & Sons, Inc., New York, 1st edition, 1967.

49. *Solubility and pH Calculations* by J. N. Butter, Addison-Wesley Publishing Co., Inc., Reading, Mass., 1st edition, 1964.

50. *Gas Chromatography* by H. Purnell, John Wiley and Sons, Inc., New York, 1st edition, 1967.

51. *Polarography*, by D. R. Crow and J. V. Westwood, Methnen & Co., Ltd., London, England, 1st edition, 1968.

52. *Electrochemical Measuring Instruments*, by J. R. Collins, John F. Rider Publisher, Inc., New York, 1st edition, 1962.

53. *Colorimetric Determination of Elements* by G. Charlot, Elsevier Publishing Co., New York, 2nd edition, 1964.

54. *Chromatography*, edited by D. R. Browning, McGraw-Hill Publishing Co., Ltd., Maidenhead, England, 1st edition, 1969.

55. *Introduction to Chromatography* by J. M. Bobbitt, A. E. Schwarting and R. J. Gritter, Van Nostrand Reinhold Co., New York, 1st edition, 1968.

56. *Gas-Liquid Chromatography*, by S. DalNogare and R. S. Turet, Jr., Interscience Publishers, Inc., New York, 1st edition, 1962.

57. *Laboratory Handbook of Chromatographic Methods*, chief editor O. Mikes, Van Nostrand Reinhold Co., London, England, 1st edition, 1966.

58. *Elements of Stereochemistry*, by E. L. Eliel, John Wiley & Sons, New York, 1st edition, 1969.

59. *Organic Spectral Problems*, J. R. Dyer, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1st edition, 1972.

60. *A Textbook of Quantitative Inorganic Analysis*, by A. I. Vogel, Longman Group Ltd., London, 3rd edition, 1962.

61. *Titrations in Nonaqueous Solvents*, by W. Huber, Academic Press, New York, 1st edition, 1969.

62. *The Practice of Absorption Spectrophotometry*, by E. I. Stearns, Wiley-Interscience, New York, 1st edition, 1969.

63. *Applications of Absorption Spectroscopy of Organic Compounds*, by J. R. Dyer, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1st edition, 1965.

64. *Thin-Layer Chromatography*, by K. Randerath, Academic Press, New York, 2nd edition, 1966.

65. *Practical Infra-red Spectroscopy*, by A. D. Cross, Butterworth & Co., Ltd., London, England, 2nd edition, 1964.

66. *The Aldrich Library of Infrared Spectra*, by C. J. Pouchert, Aldrich Chemical Co., Inc., Published in 1930.

67. *Chemistry: Structure and Reactions*, M. K. Snyder, Holt, Rinehart and Winston, 1966.

68. *Kinetics of Chemical Process*, M. Boudart, Prentice-Hall, 1968.

69. *Structural Chemistry and Molecular Biology*, A. Rich and N. Davidson, Editors, W. H. Freeman, 1968.

70. *Distillation*, M. Van Winkle, McGraw Hill, 1967.

71. *Chemicals from Petroleum*, A. L. Waddams, Chemical Publishing Co., Inc., 1969.

PERIODICALS

1. Chemical and Engineering News

2. Chemistry

3. Analytical Chemistry

4. Journal of Chemical Education

5. Journal of the American Chemical Society

6. Environmental Science and Technology
These are published by the American Chemical Society, 1155 Sixteenth Street, N. W. Washington, D. C.

7. Scientific American, Scientific American, Inc., 415 Madison Ave., New York

8. Research and Development, Technical Publishing Co., 1301 South Grove Avenue, Barrington, Illinois

9. Industrial Research, Industrial Research, Inc., Beverly Shores, Indiana

10. Pollution Equipment News, Richard Rimbach, Publisher, 8550 Babcock Boulevard, Pittsburgh, Pa.

11. Pollution Engineering, Technical Publishing Co., Greenwich, Conn.

12. Chemical Week, McGraw Hill Inc., New York

13. Science, American Association for the Advancement of Science, Washington, D. C.

14. Environment, Scientists Institute for Public Information, St. Louis, Mo.

15. Modern Plastics, McGraw Hill Inc., New York

GOVERNMENT PUBLICATIONS

Government documents contain a wealth of information in the area of environmental studies. The most useful are published by the following departments:

1. U.S. Dept. of Health, Education and Welfare
2. U. S. Environmental Protection Agency
3. U. S. Department of Commerce
4. U. S. Department of the Interior
5. U. S. Department of Agriculture
6. Committee on Public Works, U. S. Senate
7. Office of Science and Technology

AUDIO–VISUAL AIDS

I. FILMS

A–1 Safety films purchased from Association Instructional Materials, Ridgefield, N. J. These are shown as part of the orientation in CH–101 and whenever reinforcement is deemed necessary.

Handling Solids No. yf–204
Handling Liquids No. yf–205
Handling Gases No. yf–206

A–2 Zinc Controls Corrosion purchased from Modern Talking Picture Service

A–3 Conservation and Balance in Nature, purchased from

International Film Bureau
332 S. Michigan Avenue
Chicago, Illinois 60604

B. The films which can be rented or obtained on free loan varies from year to year but the following are good sources:

1. Modern Talking Picture Service
315 Springfield Avenue
Summit, New Jersey 07901

2. Associated Films, Inc.
600 Madison Avenue
New York, N. Y. 10022

3. Shell Film Library
450 N. Meridian Street
Indianapolis, Indiana

In addition, many other chemical companies have film libraries and the chemical instrumentation companies have some useful information.

II. SLIDES

A. Chemical Reaction Principles, Parts 1 and 2

Part 1 covers these topics: Chemical kinetics and Thermochemistry. Part 2 covers these topics: LeChatelier's Principle, Reversible Reactions, Reactions to Completion and Electrochemical and Electrolytic Cells. These slides are used both in the second half of CH–101 and again in CH–225. They were purchased from Inquiry Audio–Visuals, 1754 West Farragut Avenue, Chicago, Illinois, 60640, Catalog No. 68965–M.

B. The following slide and cassette programs have been purchased from:

Communication Skills Corporation
1220 Post Road
Fairfield, Connecticut, 06430

Cat.	No.	Title	Course No.
803	Part 2	Precision and Accuracy	CH–102
815		pH Measurements	CH–101, CH–102, CH–215
819		Colorimetric Analysis	CH–215
881		Chemical Equilibria	CH–101, CH–102, CH–225
882		Common Ion Effect Principle	CH–101, CH–102, CH–225
883		pH, pOH and Buffers	CH–101, CH–102
1001		Infrared Spectroscopy Instrumentation	CH–215
1002		The Column	CH–215
2001		Gas Chromatography Instrumentation	CH–215
2002		The Column	CH–215
3001		Principles of Atomic Absorption	CH–215
5001		Introduction to Mass Spectrometry	CH–215
6001		Basic NMR Phenomenon	CH–215
6002		The Chemical Shift and NMR	CH–215

C. The following slide sets, with printed narration, have been purchased from:

James L. Ruhle and Associates
P. O. Box 4301
Fullerton, California, 92631

They are especially for the Environmental Chemistry course CH–106.

1. New Sources of Energy
2. The Storage and Disposal of Radioactive Waste
3. The Santa Barbara Oil Spill

III. OVERHEAD PROJECTUALS

A. The Chemistry set of overhead projectuals from Keuffel and Esser Co., Audiovisual Division, Hoboken, N. J. have been extremely helpful. They are of the diazo type and almost all are of the overlay type. They are listed below in numerical order with a notation made as to where they are used in the program.

Transparency Number	Title	Course Number	Unit Number
1	Kinetic-Molecular Theory-Boyle's Law	CH–101	6.1
2		CH–105	10.1
		CH–225	2.1
3	An Ionic Reaction	CH–101	5.2
4	Hydrogen Bonding in Water	CH–101	4.1
5	Evidence for Hydrogen Bonding	CH–101	4.1
6	Dissolving Sodium Chloride in Water	CH–101	10.4
		CH–102	2.3
		CH–225	6.2
		CH–105	12.1

Transparency Number	Title	Course Number	Unit Number
7	Structural Formulas of $HC1$, $HC10_2$, $HC10_2$, and $HC10_4$	CH–101	4.1
		CH–105	4.1
8	Isotopes	CH–101	1.5
		CH–105	4.1
9	Isomers of Butane	CH–201	2.1
10	Isomers of Dibro ethane	CH–201	2.1
11	Isomers of C_2H_6O	CH–201	2.1
12	Allotropes of Oxygen	CH–101	4.1
13	Allotropes of Sulfur	CH–101	4.1
14	Ionization reactions in water-liquids	CH–101	10.3
		CH–105	7.1
15	Ionization reactions in water-gases	CH–101	10.3
		CH–105	7.1
16	Hybridization	CH–201	2.1
17	Sizes of Atoms	CH–101	3.2
18	Ionic Compound–Lithium Fluoride	CH–101	4.1
19	Ionic Compound–Magnesium Oxide	CH–101	4.1
20	Covalent Compounds–Nitrogen Molecule	CH–101	4.1
21	Covalent Compounds–Ammonia	CH–101	4.1
22	Covalent Bonding–Ethane, Ethylene Acetylene	CH–101	4.1
		CH–201	Sections 2 & 3
23	Atomic Weight–Law of DuLong and Petit	CH–101	1.5
24	Atomic Structure and X–Ray Spectrometer	CH–101	3.2
25	Diagram of p and d Orditals	CH–101	3.2
26	Quantum Numbers and Atomic Structure	CH–101	3.2
27	Oxidation–Reduction (Change of Size)	CH–101	3.2, 5.2
28	Molecular Weight Based on Depression of Freezing Point	CH–101	8.1
		CH–225	6.2
29	Molecular Weight Based on Boiling Point Rise	CH–101	8.1
		CH–225	6.2
30	Molecular Weight Based on Density	CH–101	8.1
31	The Conservation of Mass–Energy	CH–101	1.4
		CH–225	4.1
32	Formula Weight	CH–101	5.1
		CH–105	5.2
33	Gay Lussac's Law of Combining Volumes and Avogadro's Principle	CH–101	6.1
		CH–105	11.1
			2.1
34	Reactions that go to Completion	CH–101	12.1
		CH–105	14.1
		CH–102	4.2
		CH–225	7.1
35	The Mole of Nitrogen	CH–101	5.1
36	Hydrochloric Acid Reactions	CH–101	Exp. 19
37	Rate of Reactions–Effect of Catalysts	CH–101	11.2
		CH–225	11.2
		CH–106	4.3

Transparency Number	Title	Course Number	Unit Number
38	Factors Affecting Reaction Rates	CH–101	Section 11
		CH–225	Section 11
39	Equilibrium Vapor Pressure	CH–101	8.1
		CH–105	7.3
		CH–225	3.1
40	Equilibrium in a Saturated Solution	CH–101	13.5
		CH–105	14.3
		CH–102	6.1
		CH–225	6.2
41	Concentration of Solutions	CH–101	10.2
		CH–105	Section 12
		CH–102	2.3
42	The Chemical Equivalent	CH–101	5.2
		CH–105	Sections 9 & 13
		CH–102	2.3
(43	Chemical Equilibrium I)	CH–101	Sections 11 & 12
(44	Chemical Equilibrium II)	CH–225	Section 7
45	Common Ion Effect	CH–102	Section 4
46	Proton Transfer	CH–102	Section 4
47	Electronegativity	CH–101	3.3
		CH–105	4.1
48	The Law of Multiple Proportions	CH–101	1.4
		CH–105	4.3
49	Periodic Table and Atomic Structure	CH–101	Section 3
50	Periodic Table of the Elements	CH–101	Section 3
51	Four Kinds of Elements	CH–101	Section 3
52	Halogens	CH–101	Exp. 19
53	Faraday's Laws of Electrolysis	CH–101	14.2
		CH–105	15.3
		CH–225	Section 9
54, 55, 56	Generating and Collecting Gases (Parts I, II and III	CH–101	Exp. 7, 8, 16, 19, 33 & 35
57	Naming Acids and Salts	CH–105	4.2
58	A Stoichiometric Problem	CH–105	Section 7
59	Balancing Equations by Inspection	CH–105	7.1
60	Oxidation Numbers	CH–101	5.1
		CH–105	8.1
		CH–102	5.1
61	Electron Transfer	CH–101	5.2
		CH–105	7.1
62	An Experimental Voltaic Cell	CH–101	14.3
		CH–105	15.1
		CH–225	10.1
63	Density	CH–101	1.2
		CH–105	Section 2
		CH–225	Section 1
64	Electroplating	CH–225	Section 9

Transparency Number	Title	Course Number	Unit Number
65	A Nelson Type Cell	CH–225	Section 9
66	Electric Resistance Furnace	CH–225	Section 9
67	Electric Furnace for the Preparation of Phosphorous	CH–225	Section 9
68	Change of State	CH–101	Section 9
		CH–225	Section 3, et. seg.
69	Cooling Curve for Naphthalene	CH–101	Section 9
		CH–225	6.2
70	Entectic	CH–101	Section 9
		CH–225	6.2
71	Hydrolysis of Dissolved Salts	CH–101	13.3
		CH–102	Section 4
		CH–225	6.2
72	Ion Absorption Resins	CH–215	Exp. 5
73	Polymers	CH–201)	Various Places
		CH–202)	
74	Production of Active Metals	CH–101	Section 9
75	Rutherford's Scattering Experiment	CH–101	Section 2
76	Half-life and the Decoy Curve	CH–101	2.3
77	Uranium Series of Radioactive Decoy	CH–101	2.4
78	Comparison of Fission and Fusion	CH–101	2.4

LEARNING AIDS

1. PERIODIC TABLES
   - A. Two wall charts (Sargent Welch Catalog number S–18805–50) are used throughout the program.
   - B. Notebook size charts are distributed to incoming freshmen. These are purchased from either Sargent Welch or Merck and Co.

2. METRIC SYSTEM CHART

   U. S. Department of Commerce

3. CHEMICAL CROSSWORD PUZZLES

   Purchased from Business Stimulus, Sauk City, Wisconsin. These are the usual type of crossword puzzles with many definitions of chemical words, symbols and phrases. They are very good for reinforcement of knowledge and at the same time are very entertaining.

4. MOLECULAR MODEL KITS

   Four types of molecular models are available to demonstrate the structure of chemical compounds.
   - A. Catalog No. 1210 Molecular Model Kit from Hamilton Ball Co., Inc., Montvale, N. J. This is the ball and stick type made of wood.
   - B. Set No. F590SRM Demonstration Basic Orbitals from Science Related Materials, Inc., Jamesville, Wisconsin, These are plastic foam models to demonstrate orbital theory.
   - C. Godfrey Molecular Models from Brownwill Scientific Division of Will Corporation, Rochester, N. Y. These are polyolefin models to scale.
   - D. Minit Molecular Models from Sargent-Welch, Springfield, N. M. These are plastic models with built in connectors. The following set is part of the Kit of the second year student.
   - E. HGS Molecular Structure Models for Organic Chemistry from W. A. Benjamin, Inc., Menlo Park, California, 94025. These are small, inexpensive plastic models for the student to use as the instructor demonstrates.

5. MODULAR SPECTROPHOTOMETER

   The CHEMANAL^R system from Sargent-Welch Scientific Company, 35 Stern Avenue, Springfield, N.J., 07081. This is a modular system with nine components of a spectrophotometer which can be used separately for educational purposes or assembled into working instruments. The modular arrangement enables students to perform many different types of fundamental experiments.

FIELD TRIPS

Field trips can be meaningful learning experiences, but they should be carefully planned and limited to two each year. During the first year, the first field trip should be to a company which has many technicians working on a variety of projects so that the new student can see for himself the nature of the work of the chemical technician.

The second trip during the freshmen year should be to get first-hand knowledge of some form of environmental problem.

During the second year the first field trip should be to a laboratory which does extensive work in organic chemistry and the fourth field trip of the program should be to a company which sells chemical instrumentation or to one which uses instruments which are not in our school laboratory.

The list which follows has suggestions for all four field trips in the order named above. Many other companies not mentioned in this list are able to enrich the student's education by means of a visit to their facilities.

I. 1. Exxon Research and Engineering Co., Linden, N.J. Exxon has such a wide diversity of projects involving chemistry that the new student will be able to understand how many types of jobs are open to him upon graduation.

2. Schering, Union, N. J.
Schering is recommended at this point since it can show the student the evolution of a chemical product from the beginning of its manufacture to its packaging and shipping in just a couple of hours.

II. 1. A field trip to study air pollution control. This could be arranged by calling or writing to Mr. Thomas Pluta, Executive Director of the Suburban Air Pollution Commission, 49 Mt. Pleasant Ave., West Orange, N.J. 07052. (201–731–1774). This field trip would give the students the opportunity to see at first hand the instruments and other equipment used in determining if a large industry or a person burning leaves was within minimum allowable air pollution standards.

2. A recycling center –
Alcoa could be contacted to arrange a field trip to their aluminum recycling center. One of the communities, such as Princeton, which separates their garbage could be contacted to determine if a field trip was feasible.

3. A sewage treatment center –
These are nearby in Elizabeth, Linden and Roselle.

4. A chemical processing company in the area which would welcome the opportunity to show the students what they are doing about their environmental problems.

III. 1. Ciba–Geigy Co., Summit, N. J.
A pharmaceutical manufacturer. During a trip through their laboratories a second year student will see in practice many of the techniques he is learning in school.

2. Mobile Chemical Co., Metuchen, N. J.
This laboratory will show the student how his knowledge of organic chemistry is used in the research on polymers and agricultural chemicals.

IV. 1. Beckman Instruments, Mountainside, N.J.
At this facility, the company has a showroom displaying their latest instruments and a service department for repairs. The student who has performed some fundamental work on the instruments in the school laboratory will be able to appreciate the sophistication of the newer and larger models.

2. Merck and Co., Rahway, N. J.
Merck is listed at this point since they have an excellent department which does research into methods of analysis. Students will be impressed by how the instruments are used in ways that were not even thought of by their manufacturers.

GUEST LECTURERS

A. Opportunities for the Chemical Technician
   1. Mr. J. Gilbert, Analytical Control Department, Merck and Co., Rahway, N.J.
   *2. Mr. R. Taborell, Schering Co., Union, N.J.
   *3. Miss C. Wilson, Exxon R & E, Linden, N.J.
   *4. Mr. N. Brown, Exxon R & E, Linden, N.J.
   *5. Mrs. M. Marsh, Ciba-Geigy, Summit, N.J.
   6. Mrs. M. Travisano, Exxon R & E, Linden, N.J.

B. Environmental Affairs
   1. Mr. R. Rothrock, Pollution Control Supervisor, E.I. DuPont
   2. Mr. T. Pluta, Executive Director of the Suburban Air Pollution Commission, W. Orange, N.J.
   3. Mr. J. Tozzi, Supervisor of Local Program Development for the Bureau of Air Pollution Control, N.J. Dept. of Environmental Protection, Trenton, N.J.

C. Quantitative Analysis
   *1. Mr. J. Nohe, Ciba-Geigy, Summit, N.J.

D. Organic Chemistry
   *1. Mrs. M. Marsh, Ciba-Geigy, Summit, N.J.

E. Thin Layer Chromatography
   *1. Mr. C. Boehm, Ciba-Geigy, Summit, N.J.

F. Gas Chromatography
   *1. Mr. N. Harris, Exxon R & E, Linden, N.J.

G. Spectrophotometry
   *1. Mr. M. Hatolski, Ciba-Geigy, Summit, N.J.

H. Nuclear Magnetic Resonance Spectrometry
   1. Miss H. Sheehan, National Starch, Somerville, N.J.

Most of those listed above are alumni of the program. They are able to communicate with the present students and are asked some very pertinent questions about their future in the chemical industry.

This is by no means a complete list. There are many alumni not listed and others who could give a lecture that would be a meaningful learning experience.

* Alumni